Jas B Burridge Guy's Hospital
Nov 28th 1805

A

TREATISE

ON THE

DIGESTION OF FOOD.

By G. FORDYCE, M. D. F. R. S.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS, AND READER ON THE PRACTICE OF PHYSIC, IN LONDON.

Cum sexaginta numeret Cassellius annos,
Ingeniosus homo est: quando disertus erit?

MART. VII. 8.

LONDON:

PRINTED FOR J. JOHNSON, N°. 72, ST. PAUL'S CHURCH-YARD.

M,DCC,XCI.

W—

TO

SIR GEORGE BAKER, BART.

PRESIDENT

OF THE

ROYAL COLLEGE OF PHYSICIANS

THIS

TREATISE

IS

DEDICATED

BY

HIS MUCH OBLIGED

FRIEND AND SERVANT,

G. FORDYCE.

ADVERTISEMENT.

THIS Treatise having been read as the Gulstonian Lecture at the Theatre of the Royal College of Physicians, the Author has subjoined the Addresses which it is usual to make to the audience before the beginning, and after the end of the Lecture.

The following work is only the physiological part of what the author means to lay before the public. Having shown in this that almost the whole difference in food

 arises

ariſes from its being more or leſs adaptea to the ſtate of the organs of digeſtion, and that only during digeſtion, he intends in a ſecond part to ſhow what ſpecies of food are adapted more, or leſs, to the preſent ſtate of the ſtomach and perhaps the other organs of digeſtion, whatever that may be.

PROËMIUM.

ROGATU tuo, Præſes ornatiſſime, cujus voluntati obſequi ſemper pro lege habebo, quorundam e viſceribus fàbricam et functiones explicare aggredior; dicturus de organis coctionis, quoque modo fiat ciborum in ſanguinem converſio. Quæ quum res ſit difficilis et obſcura, cui, ut par eſt, tractandæ, omnino me imparem ingenue fateor; oratum te velim, oratosque itidem vos, auditores plurimum colendi, ut benigni veniam mihi detis, ſicubi hallucinans levioris aliquid momenti pro argumento adferam, vel doctrinam aliquam, recta ratione non ſatis fultam et firmatam, tueri coner. Liceat quoque orare, ſi quid in medium protulero a communi ſententia alienum, ut ne me exiſtimetis vel novitatis ſtudio abreptum, vel amore hypotheſeôs inſtinctum;

inſtinctum; quippe qui ſola impulſus ſim cupidine materiam hancce ita rimandi, ut auribus veſtris non prorſus, quæ dicenda habeo, indigna viderentur. Et quanquam de rebus medicis prælegendi haud inſuetus ſum, attamen, quum auditores mei nihil fere niſi tirones ſunt, ignoſcetis, ſi reverentia virorum artis medicinalis peritiſſimorum impedimento mihi ſit, quo minus apte quam deceat eloquar.

Utar nunc, cum bona veſtra venia, ſolito eorum more, qui me in hac provincia anteceſſerunt, Anglice vos adpellandi; quo more utor libentius, veritus, ex diverſo meo linguam Latinam pronunciandi modo, ne hactenus parum intellectus ſim. Idem forſitan in noſtro ipſorum ſermone orietur incommodum ex dialecto provinciali; cui rei quum mederi penes me non eſt, veſtra uti ſpero, bonitas condonabit.

EPILOGUS.

EPILOGUS.

HOC qualicunque modo, digniſſime Præſes, Voſque hujus doctiſſimi collegii fratres, et Vos auditores omnes, adſignatum mihi munus exſequutus ſum; in quo fungendo expoſui pro virili, quibus nititur fundamentis ciborum coctio, quatenus ſcilicet eam ſtabilire et figere valuerunt magna eorum conata qui ante noſtra tempora floruere, ut et majora adhuc molimina hominum hodiernorum—ne quid dicam de mei ipſius tenuioribus conatibus, tam ſtudio quam obſervatione et experimentis, ut ad ſanitatem humanam res quam maxime conferens penitius, ſi id fieri poſſet, intelligeretur. Si neque ignota vobis neque nova dixerim, ea tamen quæ ob oculos poſui in memoriam revocare potuerunt, quæ ipſi

2 olim

olim inveſtigaveritis, quorumque felices effectus adeo mentibus veſtris inolevere, ut manu quaſi vel filo ducant in diæteticis medicinæ partibus. Si denique vos in hiſce talibus erudire auſus eſſem, id ſane futile fuiſſet, et jure merito ſummæ arrogantiæ veſtris omnium ſententiis arguerer; quocirca excuſatum me volo, quod tantum pretioſi veſtri temporis contriverim, præ deſiderio aliquid proferendi, quod, tritum licet et vulgare ſit, haud tamen inutile videatur.

ERRATA.

Page	19,	line 15,	for *illium,*	read	*ilium.*
——	21,	— 19,	— *illium,*	——	*ilium.*
——	40,	— 10,	— *gum,*	——	*of gum.*
——	65,	— 2,	— *as,*	——	*is.*
——	67,	— 19,	— *coledechus,*	——	*choledochus.*
——	84,	— 20,		add	*and expreſſed oils.*
——	93,	— 20,	for *cotylydon,*	read	*cotyledon.*
——	93,	— 23,	— *cotylydon,*	——	*cotyledon.*
——	97,	— 18,	— *cotylydon,*	——	*cotyledon.*
——	97,	— 20,	— *cotylydon,*	——	*cotyledon.*
——	106,	— 19,	— *or,*	——	*and*
——	110,	— 17,	— *and,*	——	*in.*
——	111,	— 3,	— *and,*	——	*than.*
——	134,	— 4,	— *loſes,*	——	*loſe.*
——	150,	— 8,	— *that,*	——	*when it.*
——	155,	— 14,		omit	*the.*
——	188,	— 13,	for *plumel,*	read	*plumule.*
——	193,	— 9,	— *be throwing,*	——	*threw.*

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ON THE

DIGESTION OF FOOD.

LIVING beings, both of the vegetable and animal creation, conſtantly expend ſome part of their fluids or ſolids, or both, when they are exerting any action, or performing any function of life. They may perhaps remain in a dormant ſtate for ſome time without loſs. It is neceſſary when a loſs is ſuſtained, that it ſhould be ſupplied by the addition of ſome new matter; and this new matter is called their food. If this matter has not the ſame qualities

with the matter of the parts of the body which are loſt, then it is evident that it muſt undergo a change, and be converted into a ſubſtance, poſſeſſing the ſame qualities, and conſequently being of the ſame ſpecies with that which was loſt.

Without conſidering the conſtant loſs which I have ſtated, animals, during a certain period of their lives, are acquiring new parts, and increaſing in bulk; and vegetables are continually forming new parts. It is neceſſary, therefore, that food ſhould be employed to ſupply matter for this formation and encreaſe.

There are organs in animals for receiving the food, and retaining it for a certain length of time before it paſſes into the general ſyſtem of veſſels, which we call the organs of digeſtion.

In vegetables, although the food differs from the ſolids or fluids that it is to be formed into, yet it appears to be abſorbed

by

by the ends of the fibres of the roots principally, and propelled by ſome organ ſubſiſting there, immediately into the general ſyſtem of veſſels without any previous alteration. Or it may be taken up often by any other part, as well as the root, and ſerve equally the purpoſes of nouriſhment.

One great diſtinction between animals and vegetables therefore is, that animals have organs of digeſtion, in which the food remains for ſome time before it gets into the general ſyſtem; and in vegetables the food paſſes directly into the general ſyſtem, without being detained, or ſuffering any previous alteration.

It is to be preſumed that there is ſome object to be attained by the food being ſtopped for ſome time in the organs of digeſtion of animals. The moſt obvious one is, that the food undergoes ſome change there.

In different animals the organs of digeſtion are various, and therefore it is moſt

probable that the changes which take place in different animals are different. Or that the mode of life, or ſome other accident, renders a different apparatus neceſſary for this proceſs.

There are other ſubſtances beſide the food which are poured into the cavities of the organs of digeſtion from the veſſels of the animal himſelf, which ſerve either for aſſiſting the change, or enter into the ſubſtances formed.

Our preſent ſubject, therefore, divides itſelf: Firſt, into the ſtructure of the organs of digeſtion in the human body. The ſubſtances which are applied to the food during the time of the digeſtion in the human body. The ſtructure of the organs of digeſtion, and the ſubſtances applied to the food in other animals. The qualities of the ſubſtances to be formed by the digeſtion. The ſubſtances that are capable of being digeſted, their qualities; and if ſuch qualities are different from thoſe of the

ſub-

fubftances to be formed: we are laftly to confider the manner by which the peculiar qualities of the food are to be taken away, and the qualities of the fubftances to be formed given to it.

One principal organ of digeftion in the human body is the ftomach, which I am now to defcribe.

It is the bufinefs of anatomy to fhow minutely the exterior figure, the internal ftructure, the fituation with regard to the other parts of the body, the blood veffels, the abforbents, the nerves, &c. which fupply the part to be defcribed. But it is not neceffary for underftanding the functions, or the difeafes incident to it, that all thefe things fhould be minutely attended to. It is not for example of any confequence to know from what trunks arteries, which go into the ftomach, are derived; fince they come, like the blood veffels in the other parts of the body, from the neareft larger arteries, are diftributed, anaftomofe, and ter-

minate in veins, as they do in the body generally. And the ſame thing may be ſaid with regard to the nerves, &c.

The ſtomach is a kind of ſack or bag with two openings into it. One of theſe openings is the termination of a tube which we call the œſophagus, which riſes up through the thorax, behind the lungs to the throat, where it is wider, and called pharynx, and communicates with the mouth, ſo that ſubſtances put into the mouth may be forced through the pharynx and œſophagus into the ſtomach, even when they do not tend to be carried into it by their own weight. The muſcles which force the food into the pharynx, and from the pharynx through the œſophagus into the ſtomach, it is not at preſent my object to enquire into.

The ſtomach is rather conical than cylindrical or ſpherical. It is wider and larger and bulges more out at that end where the œſophagus terminates, which termination is com-

commonly called the upper orifice of the ſtomach or cardia; from this part it approaches more to a conical form, and terminates in the other orifice, which we call the pylorus. It is raiſed up at this end, the pylorus being nearly, but not quite level with the cardia, ſo as that its upper and lower ſurfaces form as it were two concentric circles, one on the upper ſide, which is called the ſmall curvature, and one on the lower or outward and oppoſite part of the ſtomach, which is called the great curvature. They are by no means either of them of an exact circular form however, or parallel; but the ſmall curvature is more of a circular form, the large curvature bulging more out to the left from the cardia, which is like a hole opening into a large cavity, this cavity contracts by degrees till it terminates in the pylorus. Sections of the ſtomach made tranſverſely to the curvatures, are ſomething approaching to circles or ovals.

The ſtomach is ſituated immediately below the diaphragm, the cardia where the

œſophagus terminates, being nearly oppoſite to the middle of the vertebra. From thence it bulges out to the left ſide, the great curvature coming forward and downward, but more forward the fuller the ſtomach is. It paſſes on to the right ſide, riſing upwards, ſo that the pylorus is not much farther from the diaphragm than the cardia; therefore when a man is in an erect poſture, ſubſtances muſt aſcend to paſs through the pylorus. In a living animal, if there be nothing in the ſtomach there is no cavity; nor do the ſides fall flat upon one another, as they would do by their own weight, or by the preſſure of the ſurrounding ſubſtances; but it contracts ſo as to retain its proper form, and ſo as that the inner ſurfaces are every where brought into contact; and when any ſubſtance gets into it, it diſtends and enlarges the whole of it in equal proportion; eſpecially if the ſubſtance be ſolid or fluid. There is ſome doubt if this be the caſe when vapours are contained in it, for upon opening living animals, there is ſuch violence done to the

motion

motion of the inteſtines, as we ſhall afterwards have occaſion to notice, that we cannot quite truſt to the appearances of irregularity of contraction that preſent themſelves. As far as we can judge by our feeling, vapours diſtend the ſtomach unequally in ſome caſes.

It is to be obſerved, that vapour in the ſtomach, or indeed in any part of the inteſtinal canal, is always a morbid affection.

The ſtomach conſiſts externally of a membrane, which is derived from the peritonæum, which meets nearly at the interior curvature, being joined together by cellular membrane, and is reflected ſo as to cover the whole ſtomach. This membrane however, coming from both ſides, goes off at the large curvature, forming the exterior membranes of the omentum, which connects it with the ſurrounding parts. The interior ſurface is connected by means of cellular membrane, to a layer of muſcular fibres,

fibres, which run in a longitudinal direction, that is, from the pylorus towards the upper orifice, irregularly, and with whitiſh ſpaces between them, as if it were tendinous fibres, which are irregular. This layer is connected with another layer of muſcular fibres which lies within it; but the fibres of this layer run tranſverſely, one fibre not appearing to go quite round the ſtomach, but rather like ſegments of circles connected with one another, with ſomething like tendinous parts. Thoſe fibres of this layer, which are in the great curvature, have their pole, if I may ſo ſpeak, at the end of the curvature, where it bulges out, and not in the cardia. The interior layer or coat is ſtronger apparently than the outer. Between the external and internal layers, there are two other layers, of about nearly an inch in breadth, which croſs one another obliquely at the upper orifice, and are diſperſed upon the ſides of the ſtomach; and on each ſide at the ſmall extremity there is a tendinous or ligamentous band of about a third part of an inch, which

terminates

terminates in the pylorus. Theſe are ſituated between the external coat, and the outer layer of muſcular fibres *. On the inſide of the interior muſcular layer there is cellular membrane, which is looſer near the muſcular fibres, and grows gradually firmer and thicker, till it forms the baſe of the interior ſurface. Anatomiſts have commonly conſidered this as two coats, calling it the nervous and villous coat. But as far as I can judge, it ſeems to be nothing but cellular membrane growing thicker and thicker, until on the inſide of the ſtomach it becomes ſufficiently firm and cloſe to retain the ſubſtances contained in the cavity of the ſtomach; ſo that I ſhould conceive that there is, properly ſpeaking, no ſmooth or fibrous interior coat of the ſtomach at all. Obſervations made with microſcopes are extremely ſubject to fallacy from deception of viſion. On viewing the ſurface of the ſtomach with magnifiers of different kinds, and with different lights, and when the ſto-

* It is clear that by means of theſe, motion may be produced in all directions.

mach

mach is of different degrees of moiſture or dryneſs, the appearances are extremely different. The manner in which I have been able to get it moſt diſtinct, was by placing a ſmall portion of the interior part upon a ſmall circular plate of ivory, with the surface outward and in view; this ſmall plate of ivory was fixed in the centre of a circular plate of glaſs, which fitted the ſtage of a compound microſcope, and a ſilver concave mirror was applied at the object end of the microſcope to reflect the light, as uſual in viewing opake bodies. When the ſurface was moderately moiſt, there appeared a number of fine thin membranes, croſſing one another ſo as to form a number of irregular cells; and the ſurfaces of each of theſe membranes were covered again by finer and ſmaller membranes again croſſing one another, ſo as to form leſſer and ſhallower cells, ſo as very much to increaſe the interior ſurface; and this appearance accords with what is ſeen by the naked eye, or a glaſs of little magnifying power, and very much reſembles a piece of pumice ſtone broken,

broken *. In theſe cells a number of ſmall white unequal globes were ſeen lying, but detached; nor could there be ſeen diſtinctly any glandular appearance.

The ſtomach, as we have already ſaid, is never flat or flabby; but it always retains its form in the living body, and is applied to its contents. It is capable of much greater diſtenſion and contraction than any other cavity in the body. It is always full however, whether it contains an ounce or a quart, or any other quantity of any ſolid or fluid matter, as I have already obſerved.

The two orifices of the ſtomach differ from one another in this. The œſophagus, and its opening into the ſtomach, are both of the ſame ſize, ſo that conſidering the œſophagus, there is no contraction at the

* The laminæ which form theſe cells are extremely vaſcular. Some anatomiſts have ſuppoſed them covered with a fine epidermis; certainly they are not penetrable, except by veſſels in the living body.

cardia;

cardia; but this is not the caſe with the pylorus, it being contracted more than the duodenum, as well as narrower than the end of the ſtomach. So that if both cavities, to wit, the ſtomach and duodenum, are full, the pylorus would appear like a hole between them. Round this contracted part there is a particular ſet of circular muſcular fibres, which are diſtinct from both the muſcular fibres of the ſtomach and duodenum.

In the ſtomach glands are found diſperſed, in the cellular membrane under the innermoſt coat or layer of muſcular fibres. Theſe glands open by excretory ducts into the cavity of the ſtomach; the ducts have been demonſtrated in the human body by Mr. Cruickſhank, and other anatomiſts.

The glands are ſituated principally towards the pylorus.

The ſtomach is endowed with abſorbents ſimilar to the lymphatics, as they ariſe from other cavities.

The pylorus forms a communication between the ſtomach and ſmall inteſtines. Theſe have been divided into the duodenum, jejunum, and ilium. Some have diſputed this diviſion, and conſider the whole as one tube without any diſtinction. But the duodenum differs very materially from the jejunum; the difference between which and the ilium it is not my preſent buſineſs to enquire into. It is true that the preciſe point cannot be fixed at which the duodenum terminates, and the jejunum begins on the inſide; yet this does not make it proper to conſider them both as one inteſtine. For in like manner, animals and plants run into one another, ſo that it cannot be determined in ſome caſes whether a living being be a plant or an animal; yet nevertheleſs it is clear that plants and animals are totally different from one another. On the outſide the jejunum is ſaid to begin where the meſentery takes its riſe.

The duodenum begins at the pylorus, and turns immediately backwards and down-

wards

wards for a ſhort way, then turns towards the right kidney, to which it is a little more or leſs attached, and from thence it paſſes before the artery, the vein of the kidney, and vena cava, aſcending gently from the right to the left, juſt before the aorta and the laſt vertebra of the back: it continues this direction from thence obliquely forward by a ſlight curvature, which has been conſidered by ſome anatomiſts as its termination.

The exterior coat of the duodenum is derived from the peritonæum; it does not however cover the whole of the inteſtine, but the peritonæum coming from each ſide, does not meet or approach ſo near as it does either in the exterior coat of the ſtomach, or the lower inteſtines. The back of the duodenum may therefore be conſidered as without a peritonæal coat, and only covered with cellular membrane. This ſtructure of the duodenum, like the going off of the peritonæal coat of the ſtomach at the great curvature, gives an opportunity of

greater

greater diſtenſion than can take place in the lower inteſtines. Under this peritoneal coat there is cellular membrane which connects it with the muſcular coats or layers of muſcular fibres.

The external muſcular layer is longitudinal, or running in the direction of the inteſtine; not ſo ſtrong in proportion to the interior coat or layer, as that of the ſtomach to all appearance; but ſtronger in proportion, than the exterior muſcular coat or layer of the lower inteſtines, is to the interior. It is not ſo firmly connected by the cellular membrane to the interior layer as in the ſmaller inteſtines, but more firmly connected than the two muſcular coats or layers of the ſtomach. Theſe exterior longitudinal fibres cannot be traced, ſo that one fibre can be demonſtrated to run the whole length of the duodenum. Nor do they terminate in any evident tendon.

The interior coat, or layer of muſcular fibres, is tranſverſe, going round the inteſtine, the fibres not always forming a compleat circle like a ring, nor exactly perpendicular to

the line of collimation of the inteſtine; but they are ſometimes ſegments of circles, or ovals, or curves, approaching to theſe, riſing and being loſt inſenſibly. Under theſe, or within them, there is cellular membrane.

The interior ſurface of this inteſtine has very different appearances when viewed in a microſcope according to the application of that inſtrument, in many views being ſubject to optical deception. Some part of it has been deſcribed by authors as a prodigious quantity of ſmall tubercules; this appearance, however, ariſes from its being dry, or viewed with a ſide light. Near the pylorus, when viewed in the manner I have already deſcribed, it looks very ſimilar to the ſtomach, only with ſmall ridges which ſeem to run longitudinally. With an opake microſcope, nothing like pores or glands can be ſeen in it. Lower down, the ſurface appears ſomewhat more poliſhed, and tranſverſe ridges become more conſiderable, till the appearance of what are called valvulæ coniventes, gradually become more compleat.

Into this cavity two large excretory ducts enter about the bottom of the firſt curviture; one, the ductus communus choledochus bringing bile from the gallbladder and liver; the other, the excretory duct of the pancreas; theſe open together into the duodenum. The duodenum appears, as well as the ſtomach, to be capable of greater dilatation than the jejunum or ilium; for, as we have already obſerved, in the ſound ſtate of the body it is always contracted ſo as to be adapted to its contents; or if there be nothing in it, ſo that its ſurfaces ſhall be brought into contact.

The jejunum and illium differ from one another in ſome points, but not ſo much as from the duodenum, and in circumſtances which are not material to our preſent enquiry. They are ſituated in, and occupy the principal part of the abdomen; where they are coiled up, or rather hung by a membrane which we call the meſentery. It is formed by the peritonæum coming from both ſides of the abdomen, which meet at the vertebræ, and are continued on, (being connected by cellular membrane, forming a flattiſh membrane) until they

come to the inteſtine; they then divide, and paſſing round the inteſtine, unite at the back as one membrane without any diviſion; as if a piece of cloth was folded, and a finger being put into the fold, the cloth was applied cloſe to the finger and brought together at one ſide, and glued afterwards ſo as to make a double flat piece of cloth. This membrane is ſo formed, as to occaſion the inteſtines to make many volutions in ſuch manner, as that ſubſtances paſſing along them muſt ſometimes deſcend, and ſometimes aſcend. Under this there is a longitudinal coat, or layer of muſcular fibres, which are extremely fine. There is an internal layer, compoſed of fibres that go round the inteſtines in the ſame manner as in the duodenum, only that they are more attached to the exterior coat. Within this coat is cellular membrane, which thickens gradually until the interior membrane is formed. This internal membrane differs greatly from that of the ſtomach, and firſt part of the duodenum, being a ſmooth poliſhed membrane, which doubles

doubles in the diagonal direction of the intestine, and forms folds which hang loose from one another round the intestine on the interior surface, not exactly in rings; these have been called valvulæ conniventes. That these are duplicatures of the interior membrane is evident, because if we blow air into the cellular membrane, between the internal membrane and the musculars coats, they disappear. On examining their surface with a microscope, they appear again to be covered with other smaller duplicatures of the same kind. The surfaces of all these appear polished, excepting that on the edges of the smaller ridges, there is somewhat of the same cellular appearance that there is in the stomach *. The jejunum and illium are nearly cylindric, and capable of being blown up with air to a considerable size, but do not seem to distend, especially the jejunum, with any solid or fluid substance to any considerable bulk.

* The interior surface is certainly covered with an epidermis which gives this polish.

There are glands in the duodenum, lying in the cellular membrane, within the interior muſcular layer, which have orifices entering into the cavity of the duodenum, and ſimilar glands in the jejunum. Theſe ſeem to be moſt numerous in the duodenum near the pylorus.

Fluids paſs into the cavity of the ſtomach, duodenum, and jejunum, in great quantities, not only from the large glands, i. e. the liver and pancreas, but alſo from the ſmaller glands which are found, as we have already mentioned, and are numerous, in all the inteſtinal canal; and likewiſe moſt probably from exhalants: for we find not uncommonly large quantities of watery fluids thrown off from the ſtomach in vomiting, even although a former fit of vomiting not five minutes before had emptied it. Upon examination, although there was often bile and ſlimy matter thrown up in ſuch caſes; yet I have ſeen ſeveral inſtances of its being water, with a ſmall quantity of the ſalts of the blood, and

which therefore would appear to have paſſed immediately from the blood veſſels through the exhalants, without being affected by any gland. The qualities of theſe fluids we ſhall conſider afterwards.

We come now to treat of the varieties found in the ſtructure of the organs of digeſtion in other animals.

In the firſt place, in ſome other quadrupeds, and likewiſe in birds and other animals, there are reſervoirs for containing the food for ſome time previous to its entering the ſtomach where the digeſtion appears to go on, which ſtomach Mr. Hunter calls with propriety the digeſting ſtomach. In ſome animals theſe cavities retain the food in ſuch manner as to be brought back again into the mouth to be farther bruiſed and comminuted by the teeth. In others it would appear that it was reſerved in the firſt cavity to be thrown gradually into a cavity, which in birds and ſome ſpecies of fiſh is ſurrounded with a ſtrong muſcle, or

rather mufcles, and lined with a cartilaginous or horny membrane. The birds pick up ftones, which by the motion in this cavity grind the food, and perform the office which teeth do in other animals. Spalanzani, and others, have denied that they were of this ufe, and have affirmed that the ftones were picked up by mere accident, the animals miftaking them for feeds. But I have examined this particularly in experiments I made in hatching eggs with artifical heat; I have hatched vaft numbers, and frequently have given the chickens fmall feeds whole, taking care that they fhould have no ftones. In this cafe the feed was hardly digefted, and many of the chickens died. With the fame treatment in every refpect, others who had their feeds ground, or have been allowed to pick up ftones, have none of them been loft. With tolerable care, when common chickens are once hatched by artificial heat, they are eafily brought up without a hen, as by inftinct they will keep in that part of the furnace

where

where there is the proper degree of heat, and the proper expoſure to air. Inſtinct alſo teaches them what ſubſtances they ſhould chooſe for food, and what quantity of ſtones is neceſſary to intermix with it. For if a very large quantity of ſmall ſtones be mixed with a ſmall proportion of grain, they will pick out the grain, ſo that the proportion of ſtones which they ſwallow ſhall be very little, if at all greater than when only a few were intermixed. In thoſe I examined the proportions of ſtones were not at all greater when there was a large quantity of them mixed with the grain, than when there was a ſmall proportion; and I have often obſerved them chooſing one piece of ſtone, and rejecting another. Birds have alſo an evident inſtinct even to diſtinguiſh one kind of earth from another, as may eaſily be ſeen in Canary birds; the hen, at the time of her laying her eggs, requires a quantity of calcareous earth, otherwiſe ſhe is frequently killed by the eggs not paſſing forward properly, as I have in many inſtances obſerved, to one ſet of

hens

hens a piece of old mortar was given, which they broke down and ſwallowed, certainly not miſtaking it for Canary ſeed, or any kind of food, but diſtinguiſhing it from a piece of brick which they did not either break down or ſwallow; another ſet at the ſame time were kept without any calcareous earth; many of theſe died, while the others, although otherwiſe exactly in the ſame circumſtances, were none of them loſt. It appears therefore that birds have a neceſſity for ſtones being ſwallowed for digeſtion, and earths for other purpoſes, and that they have an inſtinct which diſpoſes them to chooſe the proper quantity and quality required. Moreover, as Mr. Hunter obſerves, the noiſe of the grinding may be heard, and therefore there can be no doubt that this ſtomach is made to contain ſtones for the ſame purpoſes for which teeth are employed.

In all thoſe animals which have this kind of ſtomach, there is a cavity, although not often a very large one, into which the

food

food paſſes from the gizard, and which may be conſidered as the digeſting ſtomach, analagous to the ſtomach in the human body.

The craw in birds therefore ſeems commonly to be a mere repoſitory to feed the cavity of the gizard, like the hopper to a mill; and the gizard may be conſidered as the millſtones grinding the matter that is afterwards to be digeſted in the digeſtive ſtomach.

Another purpoſe cavities in which the food remains for ſome time are employed for, may be to ſoak the food thoroughly in watery fluids, that ſo it may more eaſily be afterwards made to undergo the proceſſes of digeſtion.

Theſe previous cavities ſeem therefore to be for three purpoſes: Firſt, for a reſervoir to retain food, which is to be afterwards ground down by the teeth; ſecondly, to ſerve as a reſervoir to ſupply the gizards; and thirdly,

to make a previous maceration of food to give it a diſpoſition to enter into the digeſtive proceſs.

Animals, who live on animal food alone, have no cavity for the purpoſe of bringing the food again into the mouth to be chewed, nor any reſervoir for previous maceration. Such of them as have gizards, the contents of which are always very ſmall, require a reſervoir to contain food for ſupplying the cavity of the gizard.

In the ſtomachs of ſome animals, the glands are much larger and more conſpicuous. Perhaps they may ſecrete a fluid different from the gaſtric juice in the human body. But this we do not know by experiment.

The liver, and therefore the ſecretion of the bile, is hardly ever wanting in animals which have regular ſtomachs and inteſtines.

The

The pancreas, although very various, is wanting only in inſects.

In all animals the digeſting ſtomach is terminated by a pylorus, which divides it from the duodenum.

The duodenum is alſo diſtinct and different from the jejunum, although the exact point cannot be determined where the one ends and the other begins; and the differences are ſimilar to what we have already deſcribed in the human body.

In animals, who live on animal food, the inteſtines are ſhorter than in thoſe who live on vegetable food. Thoſe who live partly on animal, partly on vegetable food, have an intermediate length of inteſtine.

The jejunum in animals living on animal food has no valvulæ coniventes. But the ſurfaces of the inteſtines in all animals are greatly enlarged, having riſings in them of a variety of different kinds, which give

them

them an immenſe ſurface in proportion to what they would have, if their interior ſurface were perfectly ſmooth and poliſhed. The riſings which we find muſt often increaſe the one ſurface, more than the other would be many hundred times.

Theſe are the remarks which I have to make on the difference between the ſtomach and inteſtines of men, and other animals which have regular ſtomachs and inteſtines from whence fluids are carried into another ſet of veſſels, ſuch as are called blood-veſſels in the human body.

But there are animals which have no circulation of fluids as far as we can tell. For they have only one cavity, which ſerves them both for heart and ſtomach. This cavity has generally many membranes riſing up in it, which break it into a kind of different chambers, communicating with one another by large vacant ſpaces. The food is received into this cavity, and is undulated backwards and forwards from one end of it

to

to the other. This we can ſee in many of them by means of a microſcope, as I have myſelf often obſerved.

In theſe animals there is no reaſon to ſuppoſe that there is any gaſtric juice, ſuch as is found in the ſtomachs we have already deſcribed, nor bile, nor pancreatic juice.

I ſuppoſe that there are veſſels riſe from this cavity, and branch out to the ſeveral parts of the body of the animal, in the ſame manner that the juices paſs in vegetables.

Theſe animals, therefore, are ſomething between animals and vegetables. The food is digeſted in the ſtomach, and ſo far they partake of an animal nature. It is abſorbed, and carried to nouriſh the various parts of the body, and in ſo far it reſembles vegetables, which have no heart, and of courſe no circulation.

It has been a diſpute among natural hiſtorians, whether certain ſpecies of theſe were actually animals or vegetables. For example, in thoſe corals which are called keratophytons, the animal where it receives the nouriſhment, is clearly a polypus, living in a calcareous habitation which it forms like ſhell-fiſh. But it is attached to what has the ſemblance of a tree, or rather the ſtem and branches of ſome of the algi, only when diſtilled by itſelf, it yields volatile alkali, and the empyreumatic oil of animals; but ſo do the fungi, although they have been conſidered as vegetables. It is a queſtion, whether this common ſtem and branches in keratophytons is to be conſidered as dead or alive. The only reaſon for believing it to be alive, is its not putrefying; but then it is to be conſidered that both this, and the ſtems of the algi that are ſimilar to it, are hardly capable of being brought to putrefy long after all life is certainly gone out of them.

This

The ſhort ſketch which I have given of the form of the digeſtive organs in animals not of the human ſpecies, is only of ſuch parts as are neceſſary for the purpoſe of the following argument. Whoever wiſhes to be more particularly informed on this ſubject, muſt wait for my friend Mr. Hunter's publiſhing thoſe obſervations, which long and unwearied labour, joined with what ſo rarely happens, that it will exceed the belief of poſterity, a clear and accurate determination of the points which are to be illuſtrated by experiment and obſervation, and a power of inventing and proſecuting ſuch experiments and ſuch obſervations as tend to no frivolous purpoſe, but to the true evidence and illuſtration of the propoſitions brought forward, of which there are none that are not important.

I come now to conſider the ſubſtances applied to the food during the digeſtion.

It is unfortunate when it occurs in treating on any ſubject, that there is a neceſſity

of employing new terms, or adopting words already uſed, but in a different ſignification, becauſe it is ſome time before the ear adapts itſelf to a new ſound, and gives the meaning of a word to the mind without reflection, which interrupts the apprehenſion of the argument. It is equally difficult to take a word that has a vague ſenſe, and confine it to a preciſe meaning. However, it is neceſſary for me at preſent to meet this difficulty, and to uſe terms which muſt be employed preciſely to one meaning, or in one ſenſe.

A term we ſhall have occaſion to make uſe of is mucilage, which has been employed but in a very looſe and vague manner, and in a ſenſe generally different from that in which I mean to take it; ſo that I had thoughts of inventing altogether a new name. But the mind is ſo apt to reſt itſelf upon technical terms, and conceive that when they are learnt, ſcience is poſſeſſed, which opinion is the greateſt of all fallacies. This has happened unfortunately

more particularly in ſchools, and has been lately carried to a great length in ſome ſchools of medicine.

The errors ariſing from new names are greatly increaſed, if they be of Greek origin; ſince that gives them ſtill a greater power of creating veneration, and an appearance of inſpiration of knowledge. For this reaſon I chooſe to make uſe of the term mucilage, which I thus define.

Mucilage is the name of a claſs of ſubſtances; not a generic or ſpecific name.

This claſs of ſubſtances is found only in animals and vegetables.

The ſubſtances forming this claſs, if put into a water-bath, and kept expoſed to heat in open or diſtilling veſſels, all become ſolid in conſequence of water evaporating from them.

If it be in diſtilling veſſels, what we find diſtilled over is water.

If the heat employed has been moderate, ſo as not to alter the properties of the ſubſtances, and if the diſtillation has been ſuch as that fermentations have been prevented from taking place, upon returning the water diſtilled over, or an equal quantity of pure water, the matter returns again to the ſame ſtate that it was in before the diſtillation, and has exactly the ſame properties.

The ſolid matter which remains after the diſtillation is inflammable.

If the heat be encreaſed after it becomes ſolid, and the receiver be changed, there comes over a freſh quantity of water, commonly amounting to more than one half of the weight of the ſolid ſubſtance.

Empyreumatic oil and volatile alkali, or an acid likewiſe come over in vegetables, com-

commonly an acid and empyreumatic oil of a peculiar ſmell. In animal ſubſtances volatile alkali and empyreumatic oil having a different and more pungent ſmell.

But there are exceptions; for I dried ſeveral ſpecies of that claſs of plants which are called by Tournefort, cruciform; and by Linnè, tetradynamia, both by evaporation and diſtillation. The drying was performed in a bath, whoſe heat was greater than that of boiling water; it was formed of a ſolution of neutral ſalts in water; in this heat fermentations cannot take place. I put the ſolid matter left into glaſs veſſels, and diſtilled it with a red heat. The empyreumatic oil was ſimilar to that produced by diſtilling animal ſubſtances, ſuch as bones, and there was volatile alkali diſſolved in the water, and no acid produced *.

I do not know any caſe where diſtilled vegetable acid has been found on diſtilling

* Vegetable alkali was found in the reſiduum.

animal mucilage by itſelf, or an empyreumatic oil, ſimilar to that produced from moſt vegetable mucilages.

Mucilage is capable of being combined with water, and is found always naturally combined with water forming fluids, or ſolids, of a greater or leſs degree of viſcidity and flexibility, the degree by no means depending upon the quantity of water they combine with, as is ſhown from this experiment.

Farinaceous matter, ſtarch for inſtance, may be diſſolved in water in a moderate degree of heat, ſo as to form a fluid of no very great viſcidity; but boiling it, gives it immediately a great degree of viſcidity, without evaporating the water.

An idea has obtained, that when mucilage unites with water, ſo as to form a ſolid, that it has only imbibed the water into its pores, and has not combined with it chemically; but this is totally erroneous;

for

for water imbibed into the pores of any ſubſtance, which is in itſelf brittle and inflexible, cannot give it pliability or flexibility. As for example, a piece of pumice-ſtone having imbibed water into its pores, becomes indeed ſomewhat leſs brittle; the non-elaſtic power of the water preventing its vibrations, but it does not become in the leaſt more flexible or pliable. Farther, if you imbibe the water from any animal or vegetable ſolid by means of a cloth, or flour, or any mechanical means whatever, it will maintain its flexibility and pliability as perfectly as before. As alſo animal mucilages combined with the ſame quantity of water, are ſome more, ſome leſs, flexible, and pliable. For example, if we take a membrane or cartilage, and dry them thoroughly by wiping, and put them into a diſtilling veſſel, which is placed in a water bath, whoſe heat is encreaſed by diſſolving neutral ſalts in the water, the ſame quantity of water diſtills off from each; but the cartilage is much leſs flexible than the membrane before the water is thus ſeparated.

There are three modes of combination of mucilage with water. Firſt, it may be combined with water, ſo as to form a ſolid. Secondly, it may be combined with water, ſo as to form a fluid, not diffuſible through water, of which we find an example in the mucus: or it may form a fluid perfectly diffuſible through water, as the ſerum of the blood, or ſolution gum arabick are.

In all caſes I uſe the term mucilage for the ſubſtance which is left ſolid after the water has evaporated or diſtilled off in a heat which does not alter its properties, and in a manner which does not allow it to be altered by fermentation.

The next property which diſtinguiſhes theſe mucilages is, that they become entirely ſoluble in water, ſo as to form fluids by long boiling; or by being confined with water in a cloſe veſſel, ſo as to be heated to a greater degree than that of boiling water, which is commonly called Papin's digeſtion.

Mucilage, therefore, taken as the name of a claſs, includes animal and vegetable ſubſtances, ſolid, brittle, inflamable, decompoſeable by heat, capable of being combined with water in their natural ſtate, capable of being combined with water by decoction, or Papin's digeſtion, ſo as to form a fluid.

To this definition I mean to adhere ſtrictly, and eſpecially to remark that I never mean to annex the term to a ſolution of this ſolid ſubſtance in water.

This claſs of ſubſtances, to wit, mucilages, are ſubject to a particular chemical operation, which takes place in no other kind of matter whatever, and which we call coagulation.

The term coagulation has likewiſe been uſed in a very vague ſenſe. We muſt therefore endeavour alſo to make a ſtrict definition of this term, which I ſhall always adhere to.

By

By coagulation generally and vaguely has been meant the converſion of the whole of a fluid into a ſolid. Thus when a ſaturated ſolution of ammonia præparata in water, formerly called ſpirit of ſal ammoniac, is mixed with pure alkohol, the two fluids apparently become ſolid, and form a maſs which we call offa helmontiana. So when alkohol is applied to the white of an egg, a ſimilar appearance of ſolidity takes place.

There is, however, a very great difference between theſe two operations. In both caſes the alkohol occaſions the water to ſeparate from a ſolid matter: in the offa helmontiana, the alkohol attracts the water more ſtrongly than the ammonia præparata does, it unites with the water, and precipitates the ammonia præparata in ſo fine a powder, and in ſuch quantity as to take the whole of the compound of alkohol and water which is fluid to moiſten it. But if this compound of alkohol and water be ſeparated, the ammonia præparata is as ſoluble in water as it would be if it was procured,

cured by any other procefs. This then is a mere precipitation. In like manner, if we take a faturated folution of ferrum vitriolatum in water, and mix it with a faturated folution of mild fixed vegetable alkali; that is aqua kali preparati, formerly called lixivium tartari; the kali will unite with the vitriolic acid, and feparate the iron in the form of a calx; the kali vitriolatum will be partly diffolved in the water which was in the folutions before they were mixed, and partly will remain in a folid form in fine powder, which, together with the calx of the iron, will take all the fluid, to wit the folution of the kali vitriolatum, to moiften it. The whole, therefore, will become folid to appearance. This has alfo been often called coagulation. But here the calx of the iron is feparated from the acid, and united with gas, without any particular alteration in its qualities; and the alkali, which is confidered as the coagulating fubftance, is combined with the acid, and has no effect on the calx of the iron.

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On the contrary, when we apply alkohol, alum, or any other ſubſtance which coagulates the white of an egg, the alkohol, &c. unites likewiſe with the water, precipitates the mucilage from it, and ſo changes the mucilage, that it will not diſſolve in water again, as it would have done, if it had not been acted upon by the alkohol, &c. For if we take the white of an egg, and expoſe it to a heat not greater than 140°. of Fahrenheit's thermometer, we may evaporate the water, and leave the mucilage perfectly and readily ſoluble in water again. The alkohol, &c. therefore, beſides precipitating the mucilage of the white of the egg, produces an alteration in its qualities, to wit, in its ſolubility in water.

This mode of alteration of quality is totally different from all other means of altering qualities which we find in chemiſtry. For in all other caſes, qualities are only altered by combining a particle of matter, with a particle of another ſpecies of matter, or ſeparating two particles of two different

ſpecies

ſpecies that were before combined. But in the preſent inſtance no part of the alkohol, &c. unites with the particles of the mucilage, neither the alkohol conſidered as a ſimple ſubſtance, nor any of its elements; for I have diſtilled off the alkohol with a gentle heat not nearly ſufficient to coagulate the mucilage, and I recovered the whole of it, ſo that it might be applied to a freſh quantity of white of egg which it will coagulate equally, and ſo that by repeating this operation, one ounce of alkohol might have been employed to coagulate the whites of all the eggs that ever have been, or will be, produced. In like manner, without employing any greater degree of heat than that of the atmoſphere in this country; I waſhed out the whole of the alum, ſo as to procure exactly the ſame quantity that would be procured if the alum had been originally diſſolved in pure water, and not applied to the white of the egg, and the water had been again evaporated.

Animal and vegetable ſolids, as well as fluids are, as we have already obſerved, compounds of mucilage and water. Coagulation may therefore, and does, take place in animal and vegetable ſolids as well as fluids. But in ſolids it has been called by other names, as aſtriction, corrugation, tanning, &c. yet there is no difference whatever between the operation in fluids and ſolids, excepting that when the water is ſeparated from the mucilage with which it unites ſo as to form a fluid it becomes ſolid, but when the water is ſeparated from a mucilage with which it forms a ſolid naturally, it remains ſolid, but of a firmer texture.

The only difference that coagulation produces in the properties of mucilages, either animal or vegetable, is in their ſolubility in water, by occaſioning them to ſeparate partly, or entirely, from the water with which they were combined. In every thing elſe they remain the ſame in themſelves; they are equally ſolid, equally affected with heat;

they

they have the ſame colour, taſte and ſmell; they have the ſame ſpecific gravity; they are affected in the ſame manner by acids, alkalis, and all other ſubſtances that they were before their coagulation; that is to ſay, that if we coagulate a portion of any of them, and dry another portion by a heat not capable of coagulating it, ſo that in both caſes the whole water is ſeparated without decompoſing the mucilage itſelf, they are perfectly undiſtinguiſhable, excepting that that which was dried without coagulation, will combine with water again in the ſame manner that it was combined before, and that which was coagulated will not.

It is to be obſerved, that all colourleſs animal mucilages are exactly the ſame in all their properties after coagulation. This appears from many experiments that I have made, but the detail of which would be tedious and not inſtructive. Suffice it, that if the ſerum of the blood be cleared of all extraneous matter, the coagulable lymph be alſo cleared of all extraneous matter; the

white

white of an egg, the mucus, the ſkin, a tendon, a muſcle, a membrane, a cartilage, be each cleared of all extraneous matter and coagulated, it is impoſſible to diſtinguiſh by any chemical experiment or inveſtigation which was which, or what the coagulum was produced from; therefore all colourleſs animal mucilages differ from one another only in their ſolubilities in water; that is, one is ſoluble in one proportion, another is ſoluble in another proportion; one combines with water forming a fluid diffuſible through water, another forming a fluid not diffuſible through water, another forming a ſolid not diffuſible through water, of more or leſs ſoftneſs, flexibility, diſtenſility, or elaſticity.

After an animal mucilage is coagulated, it may be re-diſſolved in water by boiling it for a conſiderable time, or by macerating it in water in Papin's digeſter. And ſuch ſolution differs only in one reſpect, whatever the coagulated mucilage may have been, to wit, that the ſolution is ſometimes a little

more

more viſcid with the ſame proportion of mucilage contained. But even this difference is hardly ſenſible, if the heat employed has been very conſiderable, or the boiling continued for a very long time.

I come now to conſider the properties of the ſubſtances applied to the food, during its digeſtion in the human body, which are formed in the body itſelf, for the purpoſes of digeſtion.

Theſe ſubſtances are the ſaliva, which is formed by glands, whoſe excretory ducts open into the mouth. The gaſtric juices, which are either formed by glands in the ſtomach, or thrown out by the exhalents. The bile, which being ſecreted in the liver, and rendered more perfect in its peculiar properties in the gall-bladder, is afterwards carried into the duodenum. The pancreatic juice, which is ſecreted in the pancreas, and carried into the duodenum along with the bile. The fluids ſecreted by the glands of

the inteſtines, and thoſe thrown into the inteſtines by the exhalents.

It would lead into long details of little or no uſe to our preſent ſubject, if we were to deſcribe the ſtructure of the ſeveral glands and veſſels which furniſh theſe fluids. We ſhall, therefore, proceed to conſider the properties of the ſubſtances themſelves.

The inveſtigation of the properties of the ſeveral animal fluids by proper chemical experiments, I may ſay was hardly begun before my time, when I myſelf inveſtigated the properties of many of them, as appears by my theſis, in which the properties of mucus, and Dr. Ramſay's, in which the properties of bile, and ſome others of the ſame kind, are inveſtigated. I alſo inſtructed Mr. Hewſon, who was a pupil of mine, in the manner of inveſtigating their properties. The particular experiments which I have made to aſcertain the properties of thoſe which I am now about to conſider, would take up too much time to give

give the detail of, I ſhall therefore confine myſelf to ſhort recitals and narrations of the reſults.

The ſaliva is a fluid, conſiſting of water, with which a colourleſs mucilage, and ſaline ſubſtances, are combined. The ſaliva, the compound of theſe ſubſtances, is viſcid. It is not abſolutely indiffuſible in water, for if we rub it along with pure water in a mortar for ſome time, it may be made to diffuſe through it very equally, ſo as not to be retained by a filter, but to paſs through along with the water, or prevent the water from paſſing through. The mucilage is coagulable, but not readily: in as far as I can judge, it is coagulable by ſome of the gaſtric juices, but I have not been able to ſatisfy myſelf thoroughly in this point. The ſalts contained cannot eaſily be determined, becauſe of the difficulty of obtaining a quantity ſufficient to examine them. For although we can encreaſe the ſecretion by means of medicines, yet we have all the reaſon that can be to believe that when they

are ſo encreaſed in quantity, the quality is always very much varied; that in ſome caſes it is we are certain, becauſe the fœtor, which attends the encreaſed ſecretion in many inſtances, is a property which does not at all belong to the ſaliva in its natural ſtate: we are obliged, therefore, to truſt to ſuch experiments as we can make on ſmall quantities. That it contains ſea-ſalt there can be no doubt, becauſe if we let it evaporate properly in a glaſs veſſel, and examine the reſiduum, cubic criſtals of ſea-ſalt are plainly to be ſeen, but mixed with other criſtallizations, ſome of which reſemble thoſe of common ſal-ammoniac, whoſe criſtals are remarkable, as being double pyramids each of four ſides, joined at the baſe like thoſe of the ruby, only that the height of the pyramid is much greater in proportion to the breath of the baſe, theſe pyramids adhere to one another always at points, and ſo that the diagonals are in ſtraight lines, or form right angles with one another. Moreover, volatile alkali may be ſeparated from the ſaliva by means of fixed vegetable alkali,

and muriatic acid, by means of ſolution of ſilver in nitrous acid; muriatic acid, it is true, might be ſeparated from the ſea-ſalt. There are alſo to be found other criſtallizations of various and irregular forms, which, if one was to judge a priori, might be the ſame with the ſalts found in the ſerum of the blood.

The ſaliva has been conſidered by Mr. Macbride as a ferment. The ground of this opinion ariſes from his having made experiments, in which pieces of meat and water were mixed together alone, and where pieces of meat, water, and ſaliva were mixed together in ſimilar phials; upon letting them ſtand, air bubbles were found in the phial, in which the meat, water, and ſaliva were contained, before there were any found in the phial in which the pieces of meat and water were alone contained. The reſult was the ſame when bread and water, and bread, water and ſaliva were compared; and alſo when bread, meat and water; and bread, meat, water and ſaliva were com-

pared. But no deduction can be made from these experiments, by which the power of the saliva to induce fermentation can be grounded, because the saliva giving viscidity to the water would prevent vapours from rising in small and imperceptible bubbles; and would retain them until they became more numerous, and until they united together so as to become more sensible.

Many physiologists have considered the saliva as secreted in very large quantities during the deglutition of the food; but I can hardly be of that opinion. As far as I can judge, the secretion during a meal can hardly exceed an ounce or two, and I should think that it serves only to lubricate the passages through which the food is to pass. It is true that the great apparatus of the parotid and sub-maxillary glands, which is employed, as well as perhaps some smaller glands which open into the mouth, gives an idea that something very material is to be obtained from the effects of this fluid. But when we consider again that the mo-

ment

ment the ſaliva gets into the ſtomach, it is probably coagulated by ſome of the gaſtric juices, and then becomes exactly the ſame as any other coagulated animal mucilage, and that the ſalts are principally ſea-ſalt and ſal-ammoniac, and the quantity of water is immaterial; it is extremely problematic, whether it has any effect in the changes which take place in the ſtomach. It is true that ſea-ſalt would ſeem to ſerve ſome purpoſe in the digeſtion of the food; for wherever mankind have been enabled to procure it, they have always employed it along with the food; and not only men, but other animals. It is well known that cattle in this country thrive in ſalt marſhes. In North America ſalt is neceſſarily employed in fattening the cattle; and many animals are guided by inſtinct to eat ſalt when it comes in their way. But then the ſalt contained in the ſaliva is in very ſmall proportion, and there is at leaſt as large a quantity in ſome of the gaſtric juices, which are probably much more copious, ſo that that which is contained in the ſaliva can be but

of very little effect. I ſhould, therefore, preſume, that the ſaliva has little or no effect in the digeſtion of the food in the ſtomach.

The next ſubſtance which is applied to the food is the gaſtric juice.

Many phyſiologiſts ſeem to conceive the juices ſecreted in the ſtomach as perfectly homogeneous. But we ſhall find this to be by no means the caſe.

When an animal has been recently killed, the ſtomach being empty, there appears generally a ſmall quantity of a glary fluid, which has a coagulating power. But in vomiting, it happens often, that after one fit of vomiting, a ſecond takes place in eight or ten minutes, the patient bringing up a large quantity of a watery fluid nearly colourleſs, and ſometimes without viſcidity, and that when nothing has been given to drink, I have in many caſes examined this fluid, and found it to be water, with a

ſmall quantity of the neutral ſalts of the blood, with little or no mucilage in it, and without any coagulating power, differing therefore from the coagulating gaſtric juice. It is probably not thrown out by any gland, but by the exhalents of the ſtomach. And it is extremely probable that ſimilar fluids are thrown out during the digeſtion, as before obſerved.

The coagulating power of the gaſtric juice was undoubtedly well enough known for a very great period of time, ſince the infuſion of the ſtomach of a calf has been employed in all ages to coagulate milk to form cheeſe. But it muſt alſo be remarked, that medical authors conceived that the cauſe of milk being coagulated in the ſtomachs of infants, was owing entirely to acid produced in the ſtomach; and that, therefore, an infant's bringing up curdled milk, was a ſure ſign of acidity in the ſtomach.

Dr.

Dr. Young of Edinburgh, on examining this opinion, found that an infuſion of the inner coat of the ſtomach, which had been previouſly waſhed with water, and then with dilute ſolution of mild fixed vegetable alkali, ſo that there could not be a poſſibility of any acid remaining in it, coagulated milk very readily. He found alſo that it had a power of coagulating ſerum and other coagulable mucilages.

The coagulating power of this ſubſtance is very great. Six or ſeven grains of the inner coat of the ſtomach infuſed in water, gave a liquor which coagulated more than a hundred ounces of milk.

We cannot be ſure whether this matter be a ſolid or fluid: in either caſe it ſeems to be not very readily diffuſible through water; for in order to get out the whole coagulating power from the ſtomach, it requires that it ſhould be infuſed in water for a conſiderable length of time. Take the inſide of the digeſting ſtomach of a calf, and in-

fuſe

fuſe it in water for ſix hours, and rinſe it with clean water, and put it into a freſh quantity of water, it will ſtill give an infuſion which has ſtrong coagulating powers. Moreover, from Dr. Young's experiment of waſhing the inner coat of the ſtomach in a dilute ſolution of alkali; and afterwards infuſing it in water, and finding it ſtill give a conſiderable degree of coagulating power to the water, it would appear to be very difficultly ſoluble; otherwiſe the ſolution of the alkali would have carried it off, it having great power, even if the ſolution be very dilute, of clearing the ſurfaces of animal ſolids from any ſubſtance adhering. Further, a quantity of watery fluid being vomited up without bringing the coagulating ſubſtance along with it, ſhows that even water flowing from the exhalents, and which we ſhould therefore expect would throw off the whole of any ſubſtance from the ſurface of the ſtomach, does not bring it off.

Perhaps the cells which we have already deſcribed as forming the interior ſurface of the

the ſtomach, and which are at laſt very minute, may hide and retain the coagulating matter, ſo that watery menſtrua may not readily get at the whole of it.

The ſtomach has, beſides the coagulating matter and the watery fluids which we have deſcribed, a mucus which covers it in the ſame manner as mucus covers the ſurfaces of other mucus membranes. But it is very difficult to ſeparate theſe actually from one another, ſo as to get a maſs of each diſtinct, and ſo as to be able to examine them chemically. Poſſibly thoſe ſmall globular bodies which we diſcovered lying in the cells of the ſtomach, as before related, may be the coagulating gaſtric juice. But this is mere conjecture, and might be accidental in the ſtomachs I examined; eſpecially as they were both injected, and one of them had been preſerved in ſpirits, the globules may have been ſome part of the injection coming out without the colouring part.

Although

Although it be difficult actually to ſeparate the ſeveral juices formed in, or thrown out into the ſtomach, yet we have a clear and diſtinct idea of each of them.

The mucus having properties ſimilar to the mucus in the other parts, and which at preſent it is not our object to take notice of. I have deſcribed them above thirty years ago, in the inaugural diſſertation which it is uſual to publiſh on taking a degree at Edinburgh.

The juice which flows from the exhalents is mere water, in which the neutral ſalts of the blood are contained in larger or ſmaller proportions. And the coagulating juice is a ſolid or fluid difficultly diffuſible through water, having a ſtrong power of coagulating many animal, and perhaps ſome vegetable mucilages.

In diſeaſe, the ſtomach has a power of forming other ſubſtances, perhaps many. We ſee for example a blackiſh matter ſome-

times

times thrown off in vomiting, which certainly is not bile, it being not at all bitter to the taſte, or having the ſmell of bile. It certainly has not its colour from red particles of the blood thrown out, having nothing at all to the naked eye, or to the microſcope, of any appearance of the red particles. Sometimes ſubſtances are thrown up ſimilar to thoſe which form themſelves upon the tongue in fever, and various other diſeaſes; but of theſe ſubſtances there is not the leaſt mark in a healthy ſtomach, and it is not neceſſary, therefore, that we ſhould conſider them.

The coagulating gaſtric juice, as far as we can judge, is a colourleſs ſubſtance, and without taſte or ſmell; and, in as far as its coagulating power is uſeful or neceſſary, it does not appear that it is requiſite to be, or that it is, in any great quantity.

In the duodenum the bile is applied to the food after it has probably gone

gone through ſome proceſs in the ſtomach.

The bile varies ſomewhat, it being mixed ſometimes with a little ſerum, and ſometimes no ſuch intermixture takes place.

The apparatus for ſecreting the bile is immenſe. In all the glands of the body there ſeems to be a difference between the veſſels deſtined for the ſecretion, and thoſe deſtined for the circulation. But here the difference is very great indeed; the veſſels deſtined for the ſecretion being the veins of the abdominal viſcera gathered together, and uniting in one trunk, which enters the liver, the gland for the ſecretion of the bile, and divides in the manner of an artery, excepting that it does not appear that its branches anaſtomoſe. This peculiar ſtructure has made many phyſiologiſts conceive, that the bile was prepared in the abdominal viſcera, or the blood made ready to form it by a degree of putrefaction in the inteſtines, or ſome other operation. But on opening a liv-

a living animal, and taking blood from the vena portarum, the trunk which enters into the liver, repeating the experiment in ſeveral animals, there was no appearance of bile more than in any other of the veins. It is true that authors have been deceived as well as other anatomiſts, by examining the blood in the vena portarum, when an animal has been dead for ſome days, in which caſe the interior poliſhed ſurface of the gall-bladder is deſtroyed, and the bile ſuffered to exude and contaminate every thing near it. But that is not the caſe in a living animal, or in an animal recently dead. The difference between venous and arterial blood, as far as we can gather from experiment, is only that the red particles are of a pure red in the veins, and ſcarlet in the arteries. And as we find the exhalents are conſtantly throwing out a quantity of water, together with a ſmall portion of ſerum, the venous blood muſt contain leſs water in proportion to the red particles and coagulable lymph than the arterial, although ſome phyſiologiſts have thought the coagulable lymph

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as likewiſe thrown out by the exhalents, miſled by a fallacy which it is not to our preſent purpoſe to expoſe. Nor can we draw any concluſion relative to the formation of the bile from this very ſingular mode of its ſecretion.

Many phyſicians have been led to ſuppoſe, that bile was conſtantly contained in the blood-veſſels, miſled by that very ſuperficial cauſe of deluſion, viz. the ſerum being of a yellowiſh brown colour, which they have ſuppoſed was derived from the bile. But let them take water, and mix bile with it ſo as to give it the colour of ſerum, they will find that the taſte of bile will be extremely ſtrong, ſo as to leave no doubt when compared with the yelloweſt ſerum, that its colour does not in the ſmalleſt degree depend upon the bile. Whenever bile gets into the blood-veſſels, it is ſecreted by the fineſt ſecretory organs of the body, and gives the thineſt ſecreted fluids the property of dying yellow, which always marks with certainty the preſence of bile, no other fluid

giving this quality. Another cause of error is, that there are other fluids of a yellow colour and bitter taste, but otherwise of properties totally different from the bile, such as the wax in the ear, which is both yellow, bitter, and diffusible through water; but upon the application of an acid is not decomposed, nor is there any resinous substance separated.

This part of the argument may seem digressive from the subject we are treating of, but it relates to it very strongly in this, that bile, as we have already observed, is thrown into the duodenum of all animals who have intestines as well as a stomach, and which bile is totally consumed, altered, or destroyed, in the intestines, no part of it being absorbed by the lacteals and carried into the blood-vessels.

To return to the secretion of the bile. The secretory vessels placed in every part of the liver throw the bile into ducts, very improperly called pores; it is true, indeed, that

that every hole muſt have length as well as diameter; but who would call a tube of many inches in length a pore? Theſe ducts, or tubes, unite, until they are at laſt all united into one tube, which is called the hepatic duct. From the ſide of this riſes another tube that leads into a bag which is called the gall-bladder. The bile runs through this duct into the gall-bladder, where it remains for ſome time, and grows yellower and more bitter than it was in the tubes, commonly called pori biliarii, or in the hepatic duct, it is afterwards thrown back again where it entered from the hepatic duct, and paſſes down through a continuation of the hepatic duct into the duodenum; this continuation of the duct has been called the ductus communus choledechus, through which it is obvious that either the bile ariſing from the liver immediately, or that part of it which has ſtagnated for ſome time in the gall-bladder, may paſs into the duodenum.

The bile is a compound of mucilage and water. The mucilage is not in itſelf coagulable, but ſometimes there is a mixture of coagulable matter, probably ſerum, along with it. It is capable of being diffuſed through any quantity of water, but in the gall-bladder it is united with ſuch a quantity as to render it a fluid of oleaginous viſcidity. When it is combined with that quantity of water with which it is found united in the gall-bladder, it is not more putreſcent than the ſerum of the blood. But if it be diffuſed through a large quantity of water, it putrifies much more readily.

Give me leave here to remark, that I take theſe concluſions from experiments which I have either contrived and made myſelf, or which I have got others to make under my inſpection; or which being contrived and made by others, I have either been preſent at their being performed, or have repeated them. But it would run this lecture into too great length and detail, and

draw off the attention too much from the main ſubject, to give the particular hiſtory of them.

Bile is of a yellow colour, verging ſomewhat to a green; of a bitter taſte, with ſomething like ſweetneſs. It has a peculiar ſmell, and differs but little when combined with water, as it is in the gall-bladder, in its ſpecific gravity from water. It is ſomewhat heavier.

Theſe ſenſible qualities are not of any conſequence to our preſent ſubject; we mention them only to mark, that this mucilage is very different from the colourleſs mucilages of the body. What is of more conſequence is, that the mucilage is decompoſed, not coagulated, by acids and ſome of their compounds, the acids precipitating a part, which is reſinous in ſo far as that it melts in a moderate degree of heat in the ſame manner that vegetable reſins do. It is alſo ſoluble in alkohol, but incompleatly. It has the peculiar ſmell of the ſpecies

of animals in which it is produced, and is a pretty powerful anti-putreſcent. What the other part is which the acid acts upon, has not hitherto been inveſtigated.

The mucilage of the bile ſeems to be always decompoſed in the duodenum, and the reſinous matter evacuated, ſince otherwiſe we ſhould have every reaſon to believe that it would be abſorbed by the lacteals and carried into the blood-veſſels, where, as I have already obſerved, bile is never found, excepting in a morbid ſtate of the body, that is, when a man is affected with jaundice.

The pancreatic juice is another fluid. It is ſecreted by the pancreas, a gland not unſimilar to ſome of the ſalivary glands. This gland has no reſervoir, ſo that it is difficult to come at any quantity of the juice ſecreted by it, and thrown into the duodenum. Upon inſerting a ſmall quill into its duct in a living dog, there flowed out a colourleſs fluid almoſt watery, having a

ſaltiſh taſte; and on letting it evaporate upon a plate of glaſs, criſtals were ſeen evidently of common ſalt and ſal-ammoniac, as far as we could judge by their figure, which was confirmed by applying a little of this juice to ſolution of ſilver, and making other ſuch chemical experiments as we can make on very ſmall quantities of matter, which however found rather a ground of conjecture than ſatisfactory proof. Beſides theſe ſalts, and probably the other ſalts commonly contained in the blood, there is found upon evaporation a colourleſs mucilage, which re-diſſolves in water, but whoſe compound with water is not very diffuſible through water, although ſomewhat more readily than the ſaliva. Theſe are all the properties that I could determine in the ſmall quantity that was thus collected. It is farther to be obſerved, that the ſecretion did not take place in the natural ſtate. For the quill inſerted into the duct might ſtimulate it, and occaſion a different ſecretion, at leaſt in ſome points, from that which naturally takes place; and it is impoſſible to

get a quantity of this juice collected in the duodenum, becauſe were we to tie up the ductus choiedechus ſo as to prevent bile from contaminating it, ſtill there are many other glands in the duodenum which ſecrete fluids; and there are alſo, moſt probably, exhalents that would likewiſe throw out a quantity of fluids which would alſo be mixed with it, even if we tied up the pylorus and the duodenum below the entrance of the ductus choledechus, and the ſecretory duct of the pancreas.

The other glands which are found in the duodenum we have great reaſon to believe are for the purpoſe of ſecreting ſome peculiar fluid for ſome particular uſe. But I never could contrive any means, nor do I know any have been contrived by others, by which any ſuch fluids have been, or can be collected, ſo as to be made the ſubject of experiment. Therefore our belief of their ſecreting a particular juice reſts entirely upon our not finding parts made in animals and vegetables generally without

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uſe, and finding that thoſe whoſe purpoſes we could not at firſt very well aſcertain, on further inveſtigation, were employed for very neceſſary functions.

There is mucus formed on the ſurface of the duodenum very evidently.

Theſe are the ſubſtances that ſeem particularly applied to the food, and are neceſſary or uſeful for the formation of the chyle, part of which at leaſt is compleatly formed in the duodenum. It is not therefore neceſſary that we ſhould purſue our enquiries into the fluids that may be added in the jejunum and ilium.

SUBSTANCES CAPABLE OF BEING EMPLOYED FOR NOURISHMENT.

We now proceed to conſider the next part of our ſubject, to wit, what ſubſtances are capable of being employed for the ſubſiſtence and nouriſhment of animals in general,

neral, and more particularly in the human body.

Vegetables afford nouriſhment undoubtedly for animals; but vegetables themſelves are nouriſhed. If we have but one ſeed of a vegetable, a ſeed of muſtard for inſtance, and clay, ſand, and pure diſtilled water, and the air of the atmoſphere, we can produce an infinite quantity of vegetable matter. None of the clay or ſand does any thing to the production of this vegetable matter, they only afford a ſupport to the roots and ſtems of the plants which grow in them. The water then, and the air, and other vapours which form the atmoſphere, ſupply the whole nouriſhment of plants, or vegetable matter produced.

Water is an homogeneous ſubſtance. It has been conceived lately to be a chemical compound; whether it be or no, and if it be, what are its elements, are certainly not eſtabliſhed by the experiments which have been lately made in reſpect to it.

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The vapours which form the atmoſphere are very various. We know only two of them, air and gas. Theſe make together little more than a fourth part of the vapours which conſtitute the atmoſphere. It is a queſtion, therefore, whether air, gas, or the other vapours, or water, is the pabulum, or what gives ſuſtenance and nouriſhment to vegetables.

Light has an effect on vegetation; but it may go on in perfect darkneſs; and, therefore, although light is uſeful, yet it forms no part of the nouriſhment of vegetables.

Vaſt numbers of experiments have been made to determine the effects of different vapours on vegetation. But, in my opinion, there is not any one of them which has contributed in the ſmalleſt degree to elucidate the effects of vapours of different kinds; for they have been all made on vegetables confined in a ſmall ſpace, when every one who has ſeen plants grow in an hot-houſe ſhut up from the air, will immediately

diately be convinced that appearances which take place in a plant, ſhut up in a receiver containing a gallon or two at moſt, are not to be depended upon.

There are many vegetables which grow under water. To ſee whether theſe vegetables required any thing but pure water and pure air for their nouriſhment, I ſowed ſeeds of ſeveral of them in pure diſtilled water, impregnated with pure air. The ſeeds grew, and plants were formed compleatly, ſo that there was much more vegetable matter in the whole plant than in the ſeed; and, therefore, it is clear that the other vapours which are found in the atmoſphere, beſides the air, are not at all neceſſary for the production of vegetable matter, conſequently not for the nouriſhment of vegetables.

It might perhaps have been an object that would have elucidated this ſubject ſomewhat more, if the experiment had been tried with the pureſt diſtilled water, without being impregnated with air. My object at that

time

time was only to determine whether thoſe vapours which are mixed with air in the atmoſphere were neceſſary for the nouriſhment of vegetables. But my time has generally been too much engaged to run into the inveſtigation of collateral enquiries.

Water, therefore, and pure air, are ſufficient for the nouriſhment of vegetables.

Vegetable matter ſuſtains vaſt numbers of animals. Many animals live on animal food alone; but the animals on whom they live are ſuſtained by vegetables. The lion may live on the horſe, but the horſe derives its nouriſhment from graſs. Therefore thoſe animals which live on the fleſh of ſuch other animals as are ſuſtained by vegetables, may be conſidered as ultimately living on vegetable food.

It has been a very univerſal idea, that all animals live either on vegetables, or on animals whoſe nouriſhment is derived from vegetables; but the practice of keeping gold fiſh in glaſſes with common water, without giving

them any kind of food, ſuggeſted itſelf to me as extremely ſingular, and gave ſome kind of appearance of there being either ſome animals originally in the water in which they were kept, or that inſects laid their eggs in ſuch water ſo as to afford nouriſhment to the fiſh, either from the eggs themſelves, or from the maggots, or other imperfect animals produced from them; I therefore put ſome gold fiſh into a glaſs veſſel, and ſupplied them with water taken from a deep ſpring, and which water contained a very ſmall proportion of magneſia vitriolata, and natron muriatum, together with a ſtill ſmaller proportion of calx vitriolata. This water was changed at firſt every four-and-twenty hours, and afterwards every three or four days. The fiſh lived in this manner for fifteen months, grew to more than double the ſize, and threw out conſiderable quantities of fæculent matter.

As it was poſſible that theſe fiſh might have lived upon ſomething that might be contained in the water from the ſpring, I took

took diſtilled water, and impregnated it with air of the atmoſphere, it not having been at that time known how to ſeparate pure air from the other vapours with which it was mixed. Indeed nobody at that time conceived that there was ſo ſmall a proportion of pure air in the atmoſphere, it being now known, ſince the experiments made by Dr. Prieſtly, that the atmoſphere does not contain a fourth part of its whole bulk of pure air. I put other gold fiſh into the diſtilled water ſo impregnated, and kept them for ſix months, during which time they alſo grew, and threw out fæculent matter. It might ſtill happen that ſome inſects might have formed in, or have come of their own accord into the water, which might therefore have ſerved for nouriſhment. To avoid this fallacy, I corked up the veſſel in which they were contained, and ſtill found that they lived and grew, and emitted fæculent matter, as in the former experiments. I have ſince found moreover that pure air, procured either from nitre or minium, blown into diſtilled water, ſerved

for

for their living, growing, and emiting fæculent matter.

Therefore it cannot be doubted, that animals may live on pure air and pure water; and that their fluids or folids may be immediately produced from thefe fubftances.

Although gold fifh may thus live on water and air alone, yet they have organs for digefting animal food; and when in health they, as well as other fifh, are very voracious.

If we contemplate generally the inhabitants of the fea and other waters, we fhould be at a great lofs to comprehend how fuch infinite numbers could be fupplied with food, if fome of them were not able to fubfift on water and air alone. The quantities of polypi, which in forming their habitations, produce thofe immenfe maffes of coral which rife from the bottom of the deep, fometimes almoft perpendicularly

where

where it is unfathomable by any line, could never find ſubſiſtence from vegetables, none of which grow within a thouſand miles of them.

Oyſters, and a vaſt variety of other ſhell-fiſh, are fixed to the rocks on which they grow; or they bury the remains of their progenitors, by growing upon them, without being able to go in ſearch of food, if it does not preſent itſelf to them.

The ſea is thickened with myriads of ſmall inſects and reptiles, with which it often glows as if on fire, at vaſt diſtances from any land where any vegetable could be procured.

Even herrings, and other fiſh which migrate, go in ſhoals of ſuch length, breadth, and thickneſs, that thoſe in the middle and towards the end could hardly expect to find the ſmalleſt remains of food, as it muſt all be devoured by the front of the ſhoal; yet we find that all of them have their roes

equally filled, all of them are equally fat and well nouriſhed. It is not ſo with the herds of a ſpecies of deer, called ſpring-buck, which travel in immenſe herds in the ſouthern parts of Africa, eating up every green thing in their paſſage. Thoſe in the centre and rear become emaciated and enervated, and an eaſy prey to lions, hyenas, and other carnivorous animals, which their great ſwiftneſs, when in health and ſtrength, renders them out of all kind of danger of.

Fiſh being capable of living upon water, impregnated with air, and being alſo capable of digeſting animal or vegetable food, while they cannot be preſſed for want, have all the luxury of epicures. A jack in a pond may devour all its ſubjects, and live without them ſole maſter of his dominions, while other tyrants are confined to the maſſacre of a few only, being obliged to retain ſome, often much againſt their inclination, for their own exiſtence.

Although

Although vegetables are capable of living on water and air alone, and animals are alſo capable of being nouriſhed by theſe ſubſtances, yet nevertheleſs a vegetable is better nouriſhed by abſorbing other ſubſtances into its roots, and an animal by vegetable and animal ſubſtances already formed.

I do not mean to enquire farther at preſent into the food of vegetables, but only to obſerve that they are all nouriſhed by water and air, or by ſubſtances already formed from water and air.

I proceed, therefore, in the next place, to conſider what parts of vegetables can be converted into the juices of animals.

There are various ſolids and fluids in vegetables, having a vaſt variety of different properties.

Their fluids may be conſidered as of two kinds, ſuch as on evaporation leave a muci-

lage behind, and ſuch as on evaporation leave no mucilage behind.

Excepting in as far as water may be conſidered as nouriſhment to animals, the watery parts which evaporate can hardly be conceived to be digeſted; for it is probable, that when aquatic animals are nouriſhed by water and air alone, that this water and air does not go through any proceſs in the ſtomach and inteſtines, but gets into and is altered in the body much in the ſame way as in vegetables.

All the ſolids of vegetables conſiſt of mucilages combined with water, excepting reſins and other oils or oily ſubſtances.

We may conſider, therefore, the whole nouriſhment which animals derive from vegetables as conſiſting of their mucilages.

It ſeems moſt probable, that none of the reſinous parts are digeſted: vegetable reſins,

when

when ſeparated from the other parts, we never find attacked by any animal; yet when mixed with the mucilaginous parts, they ſeem ſometimes to be conſumed either wholly or in part.

All mucilages of vegetables ſeem to be capable of ſerving for food to ſome one or other animal: we find not only farinaceous matter and other ſubſtances perfectly bland, attacked by inſects, but likewiſe jalap, ſcammony, ſicuta, and the moſt deadly vegetable poiſons devoured and deſtroyed by ſome one or other inſect. Not only the juices contained are thus found devoured, but it appears that in warm countries, where vegetation takes place very faſt, and is perhaps ſuperior to the powers of putrefaction, that there are particular ſpecies of inſects for demoliſhing all dead vegetable matter; termites eat every particle of a dead vegetable, leaving nothing behind.

All animal fluids may alſo be divided into ſuch as after the water is evaporated from

them, leave mucilage behind, and ſuch as leave no mucilage behind.

All thoſe which leave mucilage behind, are capable of ſerving for the nouriſhment of animals of ſome one or more ſpecies.

All animal ſolids conſiſt of mucilage and water; ſometimes mild calcareous earth and calx phoſphorata are depoſited in the bones or other harder parts. But in every ſolid there is always mucilage and water; and all animal ſolids are capable of giving nouriſhment to animals of certain ſpecies; therefore all animal ſolids, and fluids containing mucilage, are capable of giving nouriſhment to ſome one or other animal, even thoſe which are the moſt deadly poiſons. Cantharides are greedily devoured by two ſpecies of inſects, not part of them picked out from other parts, but the whole entirely, without leaving a veſtige of any the leaſt part of the cantharis. I have procured theſe inſects from cheſts of cantharides imported from Sicily, and which had lived upon the

cantharis

cantharis for many months. After being washed with water slightly, these insects have juices perfectly bland, so that if they be bruised and applied to any the most sensible surfaces of the human body, they produce no inflammation, nor have any appearance of possessing any matter having a stimulating quality.

In animals as well as in vegetables, there are expressed oils which appear, as we shall afterwards have occasion to observe, perfectly nutritious.

Therefore all animal and vegetable solids, and all animal and vegetable fluids containing mucilage, and expressed oils, and possibly essential oils in the form of resins, are capable of giving nourishment to some one or other species of animal.

I come in the next place to consider what substances are capable of giving nourishment to the human body.

Medicine being, as far as we can trace it in all countries in its firſt beginnings in the hands of men, infected with ſuperſtition, every part of its doctrine has conſtantly been affected with that weed, and the diatetic part perhaps more ſo than any other. We find always in the mouths of thoſe tainted with this original ſin, that man is to live naturally and on ſuch food as is preſented to him by nature. Little men, and forgetful of the Almighty's decree, that man ſhall earn his bread by the ſweat of his brow, and of courſe find out all kinds of ſubſtances from whence he is to procure ſubſiſtence; and if he cannot by his induſtry find out vegetables, or animals which may ſerve him for ſubſiſtence, he muſt cultivate and alter them from their natural ſtate. Accordingly men live, in as far as they live on vegetables, on ſuch as are no where to be found growing naturally. Wheat, rice, rye, barley, or even oats, are not found wild; that is to ſay, growing naturally in any part of the earth, but have been altered by cultivation; that is, by the induſtry of mankind,

mankind, from plants not now reſembling them even in ſuch a degree as that we can trace from whence they drew their origin; and not only theſe, but moſt of the other vegetables that we employ. A plant of ſcanty leaves, and a ſmall ſpike of flowers, not weighing altogether half an ounce, is improved into a cabbage, whoſe leaves alone weigh from fifty to an hundred pounds, without counting thoſe which are expanded, or into a cauliflower of many pounds weight, being only the embryo of a few buds, which in their natural ſtate would not have weighed ſo many grains; the plant itſelf, in its natural ſtate, not only being nothing in its bulk, but in its quality the reverſe of nutritious.

I am not, therefore, to enquire what is the natural food of man, who has no natural food; but into what he has been able to render proper for his nouriſhment, and been able to produce for himſelf by his own induſtry.

I will take this ſubject in another light. It may be thought that man is in this reſpect miſerable beyond all animals without any recompenſe: but man is deſtined to inherit the whole earth; not according to Ovid and ſome of the other ancient poets, to live only in the temperate zones, but to live and even be numerous in the torrid and both the frigid zones. The torrid zone is indeed the moſt congenial to man in his natural ſtate. There vegetation and animation go on ſo quickly, that food is eaſily procured, and raiment is not wanting: but other difficulties occur perhaps from ravenous animals, violent diſeaſes, and other circumſtances which are quite foreign to our preſent ſubject, and which I ſhall not digreſs into. Suffice it to ſay, that I am to enquire into what food human induſtry has found for the human ſpecies.

The firſt that I ſhall take notice of is a vegetable mucilage, which is called farinaceous matter.

Farina-

Farinaceous matter is found moſt particularly in the ſeeds of that great diviſion of plants called gramina: a diviſion which has been particularly conſidered, and appears to be principally intended for the nouriſhment of animals.

Some of theſe gramina have been altered, as I have already hinted at, by cultivation, ſo as to afford ſeeds much larger, and therefore giving a much larger quantity of nouriſhment than they do in their natural ſtate. It would be carrying this reſearch into too long a detail to enter minutely into the deſcription and cultivation of this principal food of mankind. We ſhall content ourſelves with the following obſervations.

The gramina, as well as the other plants known and uſed by the Greeks and Romans, are ſo ill defined, that we cannot tell certainly what they made uſe of, or whether thoſe remain which they had brought to perfection, or whether they have been loſt, and others have been brought anew from

from natural plants, which have been varied from their natural ſtate, ſo as to produce them.

Rice can only be cultivated in warm climates, and in lands either altogether or nearly overflowed with water. This grain contains more nouriſhment for its bulk than any other pure farinaceous feed whatever. It has however a ſmall quantity of aſtringent matter mixed with the farinaceous, and between the huſk and the ſeed there is a ſmall proportion of ſugar. Rice delighting in moiſture, although the crop be heavy, does not exhauſt the ground ſo much as might be expected.

Wheat, for its bulk, contains farinaceous matter next in proportion to rice, and has the farinaceous matter more pure than any other ſeed, having the leaſt aſtringent matter mixed with it, and very little if any ſugar between it and the huſk. As it is the pureſt and beſt grain, ſo it requires the greateſt labour in its cultivation.

The

The other ſpecies of grain may be conſidered only as ſubſtitutes for rice and wheat, and are only cultivated for food, where wheat or rice will not grow, or where wheat exhauſts the ground to ſuch a degree, as that it is not capable of bearing ſucceſſive crops of it. We may except maize, which in moderately warm countries is eaſy of culture, and produces large quantities of farinaceous matter, mixed however with ſuch aſtringent matter as gives it ſomewhat of a diſagreeable taſte.

The farinaceous matter in the ſeeds of all the gramina, is the ſame as it is alſo in all other plants, and parts of plants which produce it.

In the ſeeds of the gramina there are three ſubſtances, beſides farinaceous matter. Sugar generally contained between the huſk and the cotylydon, or between the external huſk, which was formerly the flower and the proper ſeed, conſiſting of the huſk, cotylydon and embryo; this ſugar is moſt

probably produced during the flowering, and has not been deſtroyed; it is in largeſt quantity in rice and rye. Secondly, a mucilage, which is very apt to fall into fermentation, and which is in the largeſt quantity in rye and barley, ſo as to render them ſomewhat apter to fall into fermentation. Thirdly, an aſtringent juice apparently ſimilar to the ordinary aſtringent matter in other vegetables.

That the farinaceous matter is the ſame in all theſe ſeeds, and only mixed with theſe other extraneous matters is evident, becauſe theſe other ſubſtances may be deſtroyed by ſteeping the ſeeds either with or without the huſks in water for ſix or eight hours, pouring off the water, and applying freſh, and ſo perſiſting for ſome time, until the other ſubſtances are waſhed off, or deſtroyed by fermentation. The farinaceous matter remains ſolid, and in a fine powder. If the huſks were preſent and the whole be bruiſed down and paſſed through a ſieve, the farinaceous matter ſubſides in the form

of a white ſolid ſubſtance, and may be ſeparated from the water by ſubſiding, filtration and evaporation; it is found to be the ſame in all its qualities from which ever of theſe ſeeds it is procured, and is called ſtarch.

We muſt not, however, conſider ſtarch as farinaceous matter, abſolutely free from any alteration, although there ſeems to be a very ſmall degree; for thoſe parts of it which have undergone any fermentation are probably waſhed off, along with the other extraneous matters mixed with it in the ſeeds.

Another natural claſs of plants which have been called legumina, plants having flowers which have been thought by ſome botaniſts to reſemble a butterfly, and which by Linnè are called, according to his whimſical denomination of claſſes, diadelphia decandria, ſeem alſo deſtined very much for the food of animals; but all of them are naturally unfit for the nouriſhment of mankind.

kind. By culture an aſtringent matter, which is found in their ſeeds is deſtroyed, ſo that the farinaceous matter which they contain is rendered ſufficiently pure for uſe: nevertheleſs the ſame culture produces in them a conſiderable quantity of that mucilage which is ſo apt to fall into fermentation.

Perhaps this claſs of vegetables might not be cultivated ſo as to produce ripe ſeeds for food, if it were not for the advantage the farmer finds in taking alternate crops of them and the gramina.

Nuts are ſeeds of trees generally, but ſo various in their botanical diſtinctions, that they cannot be claſſed otherwiſe, than that there is an external hard covering, within which, when it is firſt formed, there is ſomething ſomewhat reſembling cellular membrane in an animal. In the middle of this is the embryo of the ſeed contained in a peculiar membrane, and in which is included the embryo of the young plant after the

the flower is over. Within this membrane a white, and what has been called a milky juice, is formed and contained. This milky juice confifts of fugar mucilage, difpofed to fermentation, and probably expreffed oil; of this however, I only judge by external appearances. That there is oil has not been clearly made out by any experiments that I know of; and I have never had time to inftitute a fet of experiments to determine the point. By degrees this milky juice thickens, increafes, and expands or dilates the internal membrane in which it is contained, the cellular membrane between it and the hufk being gradually compreffed, apparently killed, and rendered fibrous, until the membrane, covering what has now become two cotylydons, generally is applied to the external hard coat, which we call the fhell.

The cotylydons confift of farinaceous matter, mixed with a large quantity of expreffed oil, and fometimes a bitter juice, which has been held in fome cafes poifonous, but, that it is, admits of very confider-

able doubt. Effential oil is very often found in large quantities, in the hufks of thefe nuts. It is a queftion whether it is not alfo in fome inftances difperfed through the cotylydons, but that is not perfectly determined.

The expreffed oil contained in thefe nuts, has the property of preventing the other matters from being wafhed off, in fuch manner as to form ftarch from them, by any means I have hitherto been able to employ; but their coagulability by heat and other properties, fhow clearly that they contain a large proportion of farinaceous matter.

There are many other feeds of vegetables of various claffes that abound with farinaceous matter, and which might be employed for nourifhment, if human induftry had exerted itfelf to cultivate them, as it has thofe which I have now enumerated. The feeds of the cucurbitaceæ, for inftance, contain farinaceous matter in as pure a form as the gramina, and even might vie

vie with the beſt of the gramina, as ſtarch can be equally made from them; but the quantity is like a drop in the ocean. The ſeeds of other vegetables vie with nuts in the mixture of farinaceous matter, and expreſſed oil, ſuch as for example, the ſeeds of the poppy, which poſſeſs no part of the narcotic juice of the huſk in which they are contained.

I am inclined to think that fruits of vegetables alſo contain farinaceous matter, even apples, peaches, apricots, and more particularly perhaps the bread fruit. But this opinion is but a conjecture, no experiment having been made to aſcertain it.

The ſtems of ſome vegetables, particularly of that natural claſs which is called palmæ, I alſo ſuſpect to contain farinaceous matter, a powder, according to the accounts which we receive from the countries in which they grow, being beat out of them, made uſe of for nouriſhment, and formed into a ſubſtance we call ſago; which al-

though it cannot be well determined without opportunities which are not eaſily procured in this country, I have great reaſon to conjecture to be the product of farinaceous matter.

The roots of plants of many claſſes contain large quantities of farinaceous matter; of theſe the potatoe contains it in the pureſt form, and is emulous of the ſeeds of the gramina. Beſides the farinaceous matter, it contains evidently a conſiderable quantity both of ſugar and that mucilage which is diſpoſed to fermentation; but it is void of the aſtringent matter which exiſts perhaps in the ſeeds of all the gramina, although not ſo diſcernable in wheat, rye, and barley. The other matters may be eaſily waſhed off, ſo as to leave a farinaceous matter in the form of ſtarch.

There are ſome roots, ſuch as bunium bulbocaſtanum, which are natives of this country, that have farinaceous matter nearly as pure as potatoes; but theſe do not grow wild in

a quantity ſufficient to render them of account, neither have they been cultivated. Various other roots of different natural claſſes grow in warm countries, with moderate cultivation, ſuch as yams, ſweet potatoes, &c. which contain farinaceous matter in ſuch quantity, as that the other ſubſtances may alſo be waſhed away, and ſtarch be left. Theſe contain a larger proportion of ſugar than thoſe we have already mentioned.

Theſe are the ſources from whence farinaceous matter is obtained for nouriſhment.

There are ſeveral ſubſtances which are contained in a variety of different vegetables; which nevertheleſs, when extraneous matters are ſeparated from them, ſo that they are obtained by themſelves pure, are found to be the ſame ſpecies of matter. Thus it is the ſame ſugar which is contained in all plants. It is the ſame blue matter which affords, with a mixture of yellow, the green in the leaves

of all vegetables. So from whatever ſource farinaceous matter is derived, it has always the ſame properties.

It conſiſts of a mucilage, combined with water ſo as to form a ſolid. It ſeems to be depoſited in very fine particles in extremely ſmall cells, as appears by the fine powder it eaſily falls into when ground in a mill. If it was an uniform ſolid, the grinding would by no means produce ſo fine a powder. When the cells are deſtroyed by ſoaking it in repeated waters it falls into an extremely minute powder, without much tritiratation, which it could not do if it was in a ſolid maſs; as in that caſe the outſide only would be ſoftened or diſſolved. It is hardly ſoluble in water heated to leſs than 100° of Fahrenheit's thermometer, excepting ſome fermentation ſhould take place in it. It diſſolves in water in a heat from 160° to 180° forming a viſcid ſolution. An heat above 180°, coagulates it, whether it be applied to the farinaceous matter immediately, or whether it be applied

plied to a ſolution of it in water. It diſſolves by long boiling in water after it is coagulated, and now forms a ſolution not near ſo viſcid, adheſive, or tenacious, as it does when diſſolved in a leſs heat than is ſufficient to coagulate it.

Farinaceous matter is perhaps the principal nouriſhment of mankind; and not only of mankind, but of other animals whoſe organs of digeſtion approach near to thoſe of the human ſpecies.

Yet men do not uſe this ſubſtance without preparation, even after they have had the neceſſary labour of cultivation; for in all countries, where fire can be procured with any tolerable eaſe, they have always coagulated it by heat, and ſometimes more firmly by alkohol, alum, and other ſubſtances, which have the power of coagulating it as well as heat.

The next ſubſtance taken from vegetables, which men uſe for nouriſhment, is ſugar.

This ſubſtance is found in every vegetable, excepting the fungi, if they be vegetables. It muſt alſo be obſerved, that there is no evidence of its being contained in lichens, moſſes, or algi, although from their taſte one would be led to believe that it is alſo contained in theſe. I have procured pure ſugar from a great variety of the different claſſes of plants from the gramina, liliacea, plantæ, palmæ; from trees, ſhrubs, and herbaceous vegetables; from each of them of various natural claſſes, ſo that I have no doubt but it may be procured from all of them.

The proceſs is eaſy: take any of the parts of an annual which are growing; or in a perennial take the juices at the time it is making its annual ſhoot; the quantity of juice to be collected muſt be ſeveral gallons, mix it with an equal quantity of a ſaturated ſolution of lime in water; boil them together briſkly, taking off the ſcum as it riſes, until the heat of the boiling liquor is 234° of Fahrenheit's thermometer;

let

let it cool ſlowly, and cryſtals of ſugar will often be found at the bottom. If they are not, mix the maſs with the ſame quantity of the lime water, and evaporate it again: if cryſtals of ſugar are not now formed, the mixture and evaporation are to be repeated, and the evaporation continued till the heat is from 244° to 246°. It is material that the boiling ſhould go on very quickly.

But although ſugar is thus found in all vegetables, yet its ſources for the purpoſes of food are not very general, being confined principally to grapes, figs, dates, and ſome other fruits. Fruits indeed in general contain ſugar; many of them in ſufficient quantity to afford conſiderable nouriſhment. But the three ſpecies which I have enumerated, are thoſe on which many perſons live almoſt entirely, the ſugar being nearly their only nouriſhment; as dates in ſome of the African provinces, grapes in ſome parts of Portugal and Spain, and figs in parts of Greece, and the Grecian iſlands. I do not ſay that

in theſe countries all the inhabitants live upon theſe fruits alone, but many do.

In theſe fruits there are mixed with the ſugar the vegetable mucilage, prone to fall into fermentations itſelf, and to carry the ſugar as well as other matters along with it into fermentation, as appears clearly, by taking a ſolution of pure ſugar, and a quantity either of the juice of the fruit in its recent ſtate, or an infuſion of it when dried, and putting them under the ſame circumſtances, i. e. in a heat of 55 degrees, and a moderate expoſure to the air; we find that the recent juice or infuſion of the fruit will enter readily into fermentation, while the ſolution of the pure ſugar will remain unaltered.

Both farinaceous matter and ſugar are contained in the roots of umbeliferous plants, or receptacles of the flowers of the ſyngineſia.

Sugar when purified, that is, ſeparated from all extraneous matter, is a mucilage, capable of combining with water ſo as to form cryſtals, which are readily ſoluble in

nearly

nearly half their weight of water, in a heat of 50°. of Fahrenheit's thermometer, forming a viſcid ſolution, which is readily diffuſible through any quantity of water, in any heat the water will bear.

Expreſſed oils found in vegetables are alſo capable of being digeſted. The ſeeds containing them, and eſpecially nuts, are in many inſtances the principal food of the inhabitants of a country, as cocoa nuts for inſtance, both in America and in the Eaſt. It is true that theſe ſeeds likewiſe contain farinaceous matter; but then the farinaceous matter is not nearly in ſuch proportion as to give nouriſhment alone in the quantity made uſe of.

I ſhall have occaſion to bring forward this ſubject more fully afterwards.

The next ſubſtance which is found in vegetables, capable of giving nouriſhment to mankind, is gum.

Under the name of gum almoſt all vegetable ſubſtances have been ſometimes included

which are perfectly colourlefs, infipid, and inodorous in themfelves; and which, when the juice of a plant oozes out naturally, upon the waters evaporating, leave a folid which is infipid, inodorous, and colourlefs, and diffolves in water fo as to form a vifcid folution. But of thefe juices and fubftances there are feveral which do not agree. Gum tragacanth for inftance, having many of the properties of farinaceous matter. Thofe which I mean to take notice of at prefent, are gum arabic, feneca, cherry-gum, and others which are fimilar.

Thefe, when found naturally in the plant, are combined with water, forming a folution of a vifcidity in proportion to the concentration of their folution. They are not coagulable by heat, as is the cafe with gum tragacanth, and others of that kind. They are, however, coagulable by fome applications, fuch as lithargyrus acetatus. They differ from the mucilage difpofed to fermentation, and the mucilage which prevents fermentation at leaft in this quality, that they

have

have neither the one nor the other diſpoſi-tion.

This mucilage is no where cultivated for food, or even collected; ſo that we ſhould be apt to conſider it as incapable of afford-ing any nouriſhment, if it were not that it has happened that the caravans croſſing the ſandy deſerts of Africa, over which they have brought gum ſeneca, have in many in-ſtances loſt their way, exhauſted their pro-viſions, and been obliged to live on this gum for many weeks, having nothing elſe but water alone, and that even very ſparing-ly; but we know that a man can hardly live without food for more than ten days.

Another colourleſs mucilage is contained in almoſt all vegetable juices, which is not only in itſelf very apt to fall into fermenta-tion, but is alſo extremely powerful in leading other vegetable matters into fer-mentation, as I have already taken notice of.

This

This mucilage I have never been able to ſeparate by itſelf, ſo as to inveſtigate its properties; nor have I been able to determine whether it be a digeſtible ſubſtance or not. But it has powerful effects in the digeſtion of every ſubſtance with which it is mixed, and which I ſhall have occaſion to notice afterwards.

It is contained in every vegetable, and in every part moſt probably, but more particularly in the root, or what is the ſame, the ſtem of perennial plants, when the annual ſhoot is juſt about to be puſhed out; in the growing part of all vegetables; in the flower; and in that pulpy ſubſtance which envelopes the ſeeds and fruits. It is alſo in larger proportion in particular natural claſſes, ſuch as the cruciform plants, or according to Linnè's whimſically named ſyſtem, tetradynamia, and ſome others.

But there is alſo another mucilage, which is the very reverſe. It is likewiſe combined with water in the vegetables contain-

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ing it; but when it oozes out from a wound ſeems rather to concrete, and become ſolid by evaporation, as may be ſeen on breaking an unripe cucumber, and letting its juice ooze out. This ſubſtance reſiſts fermentation; whether it be digeſtible or no, I alſo have not been able to determine; moſt probably, however, it is, ſince unripe fruits of the cucurbitacea are cultivated in ſome countries, as the principal part of the nouriſhment for a certain ſeaſon of the year.

The next ſubſtance which we may ſuſpect to be found in vegetables, and to be digeſtible, is native vegetable acid. But there are no good grounds for determining whether it be or be not, only that it ſeems, as far as experiments looſely as they have been made in many points of medicine ſhow, to prevent the ſea-ſcurvy, when men have been obliged to live on ſalted animal food.

The fungi are a claſs of ſubſtances which ſome have rather conſidered as animals than vegetables. They certainly have ſolids not

at all ſimilar to thoſe of any other vegetable, if they be vegetables. They are to be claſſed as food at leaſt, certainly with animals.

Theſe are all the ſubſtances which are found in vegetables that appear capable of giving nouriſhment to mankind, or even to have any power over the digeſtion, excepting by their effects on the organs of digeſtion conſidered as alive. For in the firſt place, the fibrous and membranous parts of vegetables are clearly not digeſted, let them be ever ſo tender or ſoft. That they are digeſtible by other animals I have already ſhown. I need only here point out what occurs to every man's obſervation, that they paſs through the inteſtines without being decompoſed; and never form in any country, or in any nation, any part of the food; otherwiſe why ſhould many rude nations, ſuch as the Indians, inhabiting ſeveral parts of America, be hardly able to keep up their tribes, when they have plenty of trees and graſs to feed upon, if theſe would ſerve for nouriſhment. It would then be no inhumanity to ſend a colony to drive a part of mankind ſo wretched,

ed, as hardly to be able to ſubſiſt on the ſhell-fiſh that are thrown upon their ſhore into the inland part of their country, where there are plenty of graſs and trees, if they could but feed upon them. But ſuch food cannot be digeſted in the human ſtomach, in conſequence inevitable deſtruction and devaſtation muſt fall upon that race.

There are various mucilages contained in vegetables, which have medicinal properties, and are never uſed as food.

It is true that ſome plants, naturally endowed with juices totally repugnant to the human body, nevertheleſs by human induſtry have been cultivated ſo as to deſtroy their noxious qualities, and render them proper for food, ſuch as lettuce, cabbage, &c. But then the ſame culture abſolutely deſtroys thoſe juices which would be detrimental.

There are alſo many medicinal ſubſtances found in vegetables. Theſe might act upon

the ſtomach as medicines, and afterwards be digeſted and afford nouriſhment. But this does not appear to be the caſe, for they ſeem to paſs through the ſyſtem unaltered: jalap for inſtance given to the mother, will purge the infant. The aſtringent juice of madder enters into the blood-veſſels, ſo as to colour the bones.

Almoſt all animals, in certain ſituations, afford nouriſhment to mankind, and may be eſteemed not only at firſt ſight, or on ſlight inveſtigation, to have in them an infinite variety as food, but even on more mature and perfect attention to them, they do not appear to be ſo eaſily reduced to their ſimple ſpecies, as vegetables. However, I muſt endeavour to diſcriminate the ſeveral different ſubſtances found in animals and proper for food, or capable of being digeſted.

In the firſt place, the ſolid fibres of animals differ very little in their properties, as far as they can be inveſtigated chemically. They

They all conſiſt of a mucilage, combined with water, for the calcareous earth and calx phoſphorata which are found in bones are only depoſited in interſtices. This ſeems alſo true of the ſhells of fiſhes, although in theſe the calcareous earth is in much larger proportion. In ſo far as it is contained in either, it certainly gives no nouriſhment to the human body. When theſe ſubſtances, therefore, are digeſted, it is the fibrous, or membranous, or cartilaginous parts which give the nouriſhment. The ſolids which give nouriſhment, therefore, as I have ſaid, conſiſt of mucilage and water. The mucilage is combined with the water in ſuch manner as to form a ſolid, not diffuſible through more water, if it be applied in a moderate degree of heat, without a fermentation taking place. They are all coagulable by heat, as well as by many other applications. When freed from all extraneous matter, they are colourleſs, inſipid, and inodorous. There are many other chemical properties in which

they alſo agree; ſuch as yielding, on a diſtillation by themſelves, which has formerly commonly been called chemical analyſis, empyreumatic oil of the ſame kind, volatile alkali, water, gas, inflammable air, &c. Yet they differ very much in their eaſineſs of digeſtion, which ſeems to ariſe either from their conſiſtence, readineſs of ſolution, coagulation, or readineſs of entering into fermentation, as I ſhall have an opportunity of ſtating afterwards.

All animal fluids conſiſting of coagulable mucilages and water, ſeem alſo capable of being digeſted. Theſe, however, are more various than the ſolids of animals.

The properties of the different parts of the blood, and of the other fluids of the human body, I have inveſtigated to a certain degree long ago, and publiſhed the reſults of my experiments in the Natural Hiſtory of the Human Body. There can be no doubt, but that theſe may be digeſted and afford nouriſhment; but

but ſo inhuman a practice as employing them for food is fortunately nearly baniſhed from the earth.

The fluids of other animals differ but very little from theſe in their chemical properties.

Firſt then there are the red particles of the blood, and ſimilar particles in the blood of ſome animals excepting that they are not red. As theſe have never been ſeparated from the other parts of the blood, and given by themſelves, we cannot ſay that they are certainly capable of being digeſted; the probability however is great.

The coagulable lymph, a ſubſtance which becomes ſolid on extravaſation, is certainly capable of giving nouriſhment.

The ſerum, conſiſting of a coagulable mucilage and water, is another part of the blood which is alſo capable of affording nouriſhment. There have been authors, who

from a hafty conclufion from experiments which they have not feen, have confounded this fubftance with the coagulable lymph: but it is not my bufinefs to enter at prefent on that fubject.

The white of an egg is perfectly fimilar in all its qualities to the ferum of the blood confidered feparately; for what we ordinarily call the ferum, is the ferum properly fo called, and the folution of putrefcent mucilage and neutral falts, neither of which yield any nourifhment.

The mucus, whofe properties I do not repeat now, is not proved to afford nourifhment to man; although being a colourlefs and coagulable mucilage, we have great reafon to believe it may, as we have alfo of all other colourlefs and coagulable mucilages. The yolk of an egg undoubtedly is capable of digeftion in the human body; moft probably, however, it has its colour from its effential oil: it is likewife a coagulable mucilage combined with water.

It

It appears clearly that the poiſonous juices of ſeveral animals, which when they are infuſed into a wound, prove almoſt inſtantly fatal, may nevertheleſs be thrown into the ſtomach, not only of many other animals, but even alſo into the human ſtomach, without the ſmalleſt detriment. I myſelf knew a black ſervant of Mr. Pitt, an Indian merchant in America, who was fond of ſoup made of rattle-ſnakes, in which the head, without any regard to the poiſon, was boiled along with the reſt of the animal.

The expreſſed oil of animals gives nouriſhment likewiſe undoubtedly; but as I have ſaid before, I reſerve the treating of this ſubject till afterwards.

Theſe then are the ſubſtances, and their various properties, which are employed to form the fluids and ſolids of the human body.

Theſe ſubſtances in the organs which I have deſcribed, and with the admixture of

the fluids which I have alſo enumerated, are converted into chyle, which is afterwards formed into blood.

It is not poſſible, without the cruelty of the Peruſian altars, to inveſtigate the properties of human chyle by experiment. But in as far as experiment has as yet been carried, the chyle of quadrupeds, a natural claſs of animals in which it is neceſſary that we ſhould rank mankind as far as he is not improved by culture, have chyle ſo ſimilar as not to be diſtinguiſhable, not even in natural claſſes the moſt oppoſite to one another in their food, ſtructure, or habits of life. The chyle of a dog or of a wolf differs in nothing, as far as can be obſerved by any experiment which has hitherto been made, from that of a ſheep or of an ox. I do not recite the experiments I have made myſelf, or that have been made by others on this ſubject, it would run theſe lectures into an unneceſſary and uſeleſs length, but they agree together perfectly in as far as experiments have been carried.

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The chyle conſiſts of three parts; a part which is fluid and contained in the lacteals, but coagulates on extravaſation. Whether the veſſels act upon it ſo as to prevent it from coagulating; that is, ſo as to keep it diſſolved in water and fluid; or whether the fluid itſelf is alive, and coagulates by death in conſequence of extravaſation, is an argument which I ſhall not here enter into. The ſecond part conſiſts of a fluid which is coagulable by heat, and in all its properties that have been obſerved is conſonant to the ſerum of the blood. The third part conſiſts of globules, which render the whole white and opake. Theſe globules have been ſuppoſed by many to be expreſſed oil; but this has not been proved. Neither has it been perfectly demonſtrated that ſugar is contained in the chyle, although it has been made very probable. What renders theſe points difficult to determine is, the very ſmall quantity of chyle that can be collected from any animal, not more than an ounce or two, at the very moſt, from one, even of the largeſt animals. However, the part coagulating on extravaſation, the part agree-

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ing with ſerum in its qualities; the globular part, which in ſome animals, but not in quadrupeds, exiſts without giving whiteneſs to the chyle alone, or along with ſugar, form the eſſential parts of the chyle.

A great many ſubſtances may enter the lacteals along with the chyle, even ſolids reduced to fine powder. When indigo has been thrown into the inteſtine of a ſheep, I have ſeen the chyle rendered quite blue: now indigo is not ſoluble in water, but is a ſolid reduced into a very fine powder. So muſk gets into the chyle giving it a ſtrong ſmell, and a great variety of other ſubſtances of various colours, various taſtes, and various ſmells, each of them giving colour, or taſte, or ſmell to the chyle. Nevertheleſs the lacteals ſeem to poſſeſs ſome power of rejection, ſince green vitriol, either exhibited along with the food, or thrown into the inteſtine after the animal has been opened while chyle was forming and abſorbing, gives no colour on infuſion of gall being applied to the chyle; nor if

galls

galls be thrown into the ſtomach along with the food; or if an infuſion of them be in like manner thrown into the inteſtine, when an animal is opened during the time that the chyle is flowing into the lacteals, do they give any colour upon a ſolution of green vitriol being applied to the chyle; the galls might be ſuppoſed to be digeſted, but the green vitriol could not; neither can we well believe that the galls could be digeſted when thrown into a portion of the jejunum of about a foot in length tied at both ends.

The lacteals, therefore, would ſeem to be ready to take in many things not digeſted, but not all. One would be diſpoſed to believe that what was injurious to the ſyſtem would be rejected by this power; yet when we conſider the great reaſon we have to believe that cantharides, mercury, and many other ſubſtances are abſorbed by them, which certainly are in many caſes deleterious, we cannot well ground any doctrine on green vitriol and galls not being abſorbed.

The

The ſubſtances which I have above pointed out to be the eſſential parts of the chyle, are totally different in all their properties from farinaceous matter, as well as the greateſt part of the other ſubſtances employed for food. A change conſequently of the properties of the ſubſtances employed for food muſt take place in the organs of digeſtion, ſo as to convert the food into theſe different ſubſtances eſſentially contained in the chyle.

THE PROCESS BY WHICH THE FOOD IS FORMED INTO CHYLE AND BLOOD.

I come now, therefore, to conſider what is the proceſs by which this change is produced, and by which the ſubſtances employed for food looſe their qualities, and acquire the properties of the eſſential parts of the chyle.

A ſimple particle of matter conſidered by itſelf, is allowed by all philoſophers, or in other

other words, it cannot be conceived but that a ſimple particle of matter by itſelf is perfectly inert and incapable of change. It may ſeem to you, Mr. Preſident, and the reſt of this learned audience, and even to the leaſt informed of any man who has entered into the paths of ſcience, that this propoſition is ſo true, ſo uncontrovertible, and ſo generally admitted, that it may be impertinent for me to bring it forward to ground upon it any argument in the conſideration of digeſtion. Yet, neverthelefs, I muſt obſerve, that moſt of thoſe who have treated this ſubject, ſeem very much to have forgot this maxim.

A ſimple particle of matter remaining the ſame, a ſubſtance cannot acquire new qualities, unleſs the Almighty ſhould pleaſe, by his all-powerful will, to change its effects on other particles of different ſpecies. Two particles of matter, therefore, of the ſame ſpecies muſt have exactly the ſpecific properties of one, only that the two will have them, if both their powers can be exerted

exerted on a third body at once, a double effect. But that effect can only be more forcible, not different. If we were to add a third, or a fourth, or an innumerable quantity of particles, the properties would ſtill be the ſame, and only, if capable of being applied together, of greater, but not of different effect. A grain of lead being projected by the force of gunpowder, may penetrate the integuments of the head, but not the ſkull; but if four hundred and eighty grains are made into a ſphere, and projected by a proportional quantity of the ſame matter, it will overcome the reſiſtance of the ſkull alſo. If the ball conſiſting of four hundred and eighty grains be divided into balls conſiſting of a grain each, each of theſe balls will ſtill have the power of penetrating, though with leſs force, and therefore will be capable only of penetrating through bodies making leſs reſiſtance. In like manner any larger or ſmaller maſs of matter of any ſpecies will have the ſame properties exactly, only that theſe properties, when they can be exerted

erted together, will have greater effect in a large mass than in a small one.

Let us take another exemplification of this subject. Suppose that we have a quantity of matter which is perfectly blue, every particle of it is blue; the blue rays of light which it reflects or transmits, strike the eye each with no other colour but perfect blue; it is seen more perfectly when there are several rays thrown from several particles so as to be formed on the retina at once; the substance impressing the mind with a stronger idea of a blue colour when the particles are numerous. But let us suppose for a moment that there is only one point in the retina sensible to light, then one particle of the blue substance reflecting one ray of blue light, would appear as blue as any mass, however numerous its particles might be, if the reflecting surface did not direct every ray to that point as a focus.

In like manner the smallest particle of vitriolic acid will have a disposition to affect the

the tongue ſo as to give an acid taſte, although the effect may be ſo faint as not to be perceived. But the impulſe of a number of particles acting on different parts of the tongue at once, will, by their accumulated powers, produce a ſenſible effect. So the ſmalleſt particle of vitriolic acid which can poſſibly, or does actually exiſt, will unite with a particle of iron ſo as to form green vitriol.

Diviſion, therefore, unleſs it be ſuch as ſeparates two particles of different ſpecies of matter chemically combined, cannot change the properties of one ſpecies of matter ſo as to form it into another.

Although this doctrine is obvious and univerſally agreed to, yet it has been by no means ſo held up to light by thoſe who have treated on the ſubject of digeſtion, as at all to govern the reaſonings which have been held with regard to it; I ſhall, therefore, ſtill put it in another light.

No

No maſs of matter conſiſts of one ſolid, uniform, perfectly compact body of matter; if it did, and remained unbroken, it would be always of the ſame bulk in every circumſtance.

Moreover, the attraction of gravity being in all matter according to the quantity of matter contained in any maſs, without conſideration of the interſtices, as has been proved by experiments on pendulums, the quantity of matter in a maſs is according to its ſpecific gravity. Now, if any ſpace was quite full of matter, the maſs would be always in ſpecific gravity equal to the ſame bulk of any other ſpecies of matter, which is not the caſe; therefore a maſs of matter conſiſts of matter and interſtices.

Further, if we take any maſs of matter and expoſe it to a greater degree of cold, it contracts. If the particles of matter touched in any one direction, they could not come nearer one another in that direction, therefore the contraction would not be equal and uniform. But the contraction of any body, when it is equally cold, is exactly equal and

uniform in all directions; consequently the particles of matter contained in a maſs come nearer, and therefore do not touch one another in any direction; therefore, the matter contained in a maſs is in ſeparate particles, not touching one another in any direction.

A particle of matter muſt be conſidered in itſelf perfectly hard, becauſe it cannot be preſſed into a leſs ſpace. If we have any idea of matter at all, the firſt and moſt abſolute quality of it is to occupy compleatly and fully the ſpace which it is in, admitting no other matter within that ſpace. It is alſo moſt perfectly inflexible, for it could only be bent by one part of it being ſeparated from another, at leaſt in all points except thoſe lying in one line.

Maſſes of matter, therefore, conſiſt of a number of ſmall particles not touching one another in any direction. When, therefore, one maſs of matter acts upon another, the particles of one maſs are not brought into contact with the particles of the other maſs. If therefore one maſs of matter ſhould divide

another,

another, it muſt act by an attracting or repelling power. That is, if I apply an iron wedge to ſplit a piece of wood, the edge of the wedge does not touch the wood, conſidering touch in a ſtrict ſenſe; but one ſide of the wedge, if the edge be a true line, repels one part of the wood to one ſide, and the other ſide repels the other part of the wood the other way, and ſo ſeparates them from one another.

The idea which I have juſt laid down of maſſes of matter being in particles quite ſeparate from one another, like many others which have perhaps originated with me, or perhaps with others that have not come to my knowledge, having crept through Europe, has occaſioned another idea to be propagated on this ſubject, the imagination of mankind not always correcting itſelf by the ſtrict powers of the judgment. Some have ſuppoſed that matter conſiſted of attracting and repelling points, not conſidering that a point is nothing, and of which, therefore, nothing can be predicated, or nothing can have no qualities. It is the

reverſe of another imagination, viz. that matter is mind, which we ſhall leave at preſent to be diſcuſſed by metaphyſicians, whoſe arguments, like a circle, have no end.

A maſs of matter, therefore, conſiſts of ſimple particles, every one of which has the exact determined ſpecific qualities that the whole maſs has, as far as theſe qualities differ from any other ſpecies of matter; for, as an example, one ſingle particle of water has exactly the ſame qualities that any other ſingle particle of water has, and equally exerts them when it is put into a ſituation in which they can be exerted.

Dividing, therefore, any of the ſubſtances we employ for food into its ſmalleſt poſſible parts or particles, cannot alter its qualities in the ſmalleſt degree, ſo far as it has ſpecific properties. The ſmalleſt particle, therefore, of farinaceous matter, ſuppoſe that it was divided into its ſmalleſt particles, cannot

cannot have a different property or properties from thoſe of farinaceous matter, and cannot therefore, by diviſion, be converted into that part of the chyle which coagulates on extravaſation, nor that part which is coagulable by heat, nor that part which we find in globules, much leſs into all theſe three parts; yet it is actually in digeſtion converted into all the three. That trituration, or dividing the food into ſmall particles, is the means of converting food into blood, is an opinion perfectly impoſſible to be true, and therefore not worth ſearching after by other experiments or arguments than thoſe I have adduced.

Modern times are thoſe of experiment. It is true that all our knowledge of every thing whatever muſt ariſe from experiment only, that is, from the evidence our ſenſes give us of what appearances nature, in other words the creatures of the Almighty, give impreſſions of. Some of theſe impreſſions are received from the ideas that ariſe from things not at all under our dominion,

or from circumſtances which he governs himſelf. Thus, for example, a man ſees a tree loſes its leaves in the autumn, ſees them renewed in the ſpring, and a new growth take place during the ſummer; he ſees the bloſſoms open in the ſpring, theſe he finds followed by fruit, which if it falls into the earth, he finds capable of producing new trees of the ſame ſpecies, or he ſees it gathered by animals and affording nouriſhment. In this mode of acquiring knowledge man is totally paſſive; he did not contrive to make leaves fall in the autumn, and be reproduced in the ſpring; he did not contrive to make new wood grow in the ſummer, nor that bloſſoms ſhould open that the ſeeds ſhould be impregnated with the embryo; he did not contrive that the fruit ſhould grow, nor did he teach animals that it was fit for their nouriſhment. What knowledge is acquired by attention to theſe natural circumſtances has been called obſervation. It is indeed a contemplation of the benevolence of the Almighty to give nouriſh-

ment

ment and happineſs to all the inhabitants of the earth.

The minds of mankind, not ſatisfied with their powers of obſervation of what paſſes in this earth, but being forced even for their own ſubſiſtence to exert themſelves far beyond the brute creation, are neceſſitated to make a farther enquiry, and that with a labour beyond the contemplation of the benevolence of the Almighty. To thoſe creatures who have only this earth to exiſt in, food and raiment are provided without labour or attention during the ſhort period of their lives. It is not ſufficient for the farmer to look where grain grows naturally; it is neceſſary to try, with an infinite variety of applications that may be made to the ground, to produce crops ſuperior to thoſe which would ariſe in it without any cultivation. It is neceſſary for the hunter not only to obſerve the natural hiſtory of wild beaſts, but alſo to try by what means he can engage them to fall into his toils. It is neceſſary for the fiſherman, beſides

admiring the multiplicity of fiſh, to be able to contrive either to entangle them or ſurpriſe them into his nets. It is neceſſary for the ſhepherd to try by what means he can increaſe his flocks, ſo as to produce greater numbers than would naturally be propagated. It is neceſſary that man ſhould try to procure better defence from the inclemency of the weather, than the caverns and other hollows of the ground which naturally offer themſelves. So, and in many other caſes it is neceſſary for mankind, not only to contemplate thoſe things which happen naturally, but likewiſe he is conſtrained to form projects of his own, and to contrive means of putting both mind and matter in circumſtances foreign to what would naturally ariſe in it, and contemplate the effects; and this we call experiment.

Obſervation then, and experiment, are the ſources of all the knowledge of mankind.

Man ſeems to have a degree of pride implanted in his nature, which prompts him

conſtantly to conſider himſelf as being far ſuperior to what he actually is, and which inſtinct is the ſureſt proof that he is to be very ſuperior indeed. But as all the virtues of mankind are balanced by oppoſite imperfections, the pride of experiment has in many inſtances thrown ſcience into confuſion, inſtead of forwarding it. An experiment to prove a thing otherwiſe demonſtrable is totally ſuperfluous; and not only ſuperfluous, but fallacious. It is perfectly clear, that if a tube be filled, and kept conſtantly full of a fluid, and placed perpendicularly, having three equal holes pierced through it, and that one ſhall be in the middle of its height, the others at an equal diſtance from it above and below, that the fluid flowing through theſe holes ſhould all be carried to an equal diſtance. Yet upon trying the experiment, it never ſucceeds without management, becauſe of the imperfection of the workman, and materials. Experiment, therefore, is often employed only as illuſtration, and not as a foundation of ſcience.

This digreſſion perhaps was not neceſſary to confute the idea that trituration could have any effect in changing food into chyle, if it were not to excuſe myſelf from taking notice of the futile, unneceſſary, and inconcluſive ground that ſome modern authors have taken for the explanation of this ſubject. I conclude the argument with this aſſertion, grounded on what I have now ſaid, that if any or either of the ſubſtances employed as food were divided into their ſmalleſt poſſible particles, they would remain ſtill in all their ſpecific properties exactly the ſame as they were when they were thrown into the ſtomach, and would never be converted either into chyle, or into blood. That no experiment, or courſe of experiments can be made to render this propoſition more or leſs evident, and that therefore all the experiments which have been made with regard to this propoſition are perfectly futile.

I come in the next place to conſider another idea which has been held with regard

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to the operation which goes on in the digeſtion of the food, to wit, that there is ſome menſtruum found in the ſtomach, which unites with the ſubſtances employed for food, and forms the different eſſential parts of the chyle. That is, for example, that farinaceous matter is capable of uniting with ſuch menſtruum, ſo as to form the part coagulable on extravaſation, the part coagulable by heat, and the part which appears in a globular form.

This opinion is undoubtedly a poſſible one, and can only be determined to be true or not by experiment; for, there may be either three menſtrua in the ſtomach, which may unite with farinaceous matter, ſo as to form the three different compounds of which the chyle conſiſts, or there being one menſtruum, it may unite in different proportions with the farinaceous matter ſo as to form theſe ſubſtances. As muriatic acid and mercury are capable of forming corroſive ſublimate and calomel, the acid and the mercury

mercury being in different proportions in the one and in the other.

Farther, the three parts of the chyle may be contained in the farinaceous matter; and the compound may be ſuch as that there may be a ſubſtance found in the ſtomach which may unite with one of the elements of the farinaceous matter, and ſet the three parts of the chyle looſe.

There is one obſervation I here beg leave to make with regard to a mode of reaſoning which has been too often adopted in phyſiology and medicine, to wit, that it has frequently been thought ſufficient to prove that a thing was not impoſſible, in order to aſcertain its actually being true. Thus, for inſtance, it has not been proved, or attempted to be proved by any experiment, that there is any ſubſtance found in the ſtomach capable of uniting with farinaceous matter, or any of its elements, ſo as to form any of the parts of the chyle, nor that there is any ſubſtance ever found in the ſtomach capable

pable of precipitating the parts of the chyle from farinaceous matter. On the contrary, the coagulating gaſtric juice, inſtead of uniting with farinaceous matter, ſo as to form chyle, has a tendency to coagulate it, if it be not coagulated before it is thrown into the ſtomach. The mucus unites with farinaceous matter, ſo as to form a thick paſte, reſembling in properties the parts of the chyle in no way, and the watery juices of the ſtomach unite with farinaceous matter, ſo as alſo to form a paſte likewiſe in no way ſimilar to the conſtituent parts of the chyle. Nor have bile, or pancreatic juice, any effect upon farinaceous matter, excepting for the water they contain. Nor do any of the fluids of the ſtomach or duodenum appear from any experiment that has been made either to unite with, or precipitate from farinaceous matter any thing like the parts of the chyle; but on the contrary, they either form a paſte with it, or have a tendency to coagulate it.

Farther, the properties of farinaceous matter, and the matter of a muſcular fibre,

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are totally different, ſo as to be actually two diſtinct ſpecies of matter. Now, although the menſtruum in the ſtomach might unite with one of them, ſo as to form the conſtituent parts of the chyle; yet the ſame menſtruum could not unite with another ſolvent, conſiſting of a diſtinct ſpecies of matter, ſo as to form the ſame compound. Vitriolic acid, for inſtance, may combine with iron, ſo as to form ferrum vitriolatum, commonly called green vitriol; but vitriolic acid can never unite with copper, ſo as to form the ſame ferrum vitriolatum, but will unite with it ſo as to form quite another compound, to wit, cuprum vitriolatum, commonly called blue vitriol; but which is totally different in its properties from the ferrum vitriolatum, excepting in thoſe properties which it enjoys in common with other metallic ſalts.

Now the three parts conſtituting the chyle are exactly the ſame, whether the matter of a muſcular fibre or farinaceous matter be digeſted; for I have fed a dog with farina-

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ceous matter, and another with the matter of a muſcular fibre, and opening them both during the time the chyle flowed through the lacteals, collecting as much chyle as could be collected from each, on examination of their properties, they both conſiſted of the three eſſential parts I have already enumerated, each of theſe parts in the one was perfectly ſimiliar, as far as I could contrive any experiment, to thoſe of the other. Whereas if it had been a menſtruum which united with the farinaceous matter, and the menſtruum had united with the matter of the muſcular fibre, the parts of the chyle formed from the one and the other muſt have been exceedingly different, as the ferrum vitriolatum is different from cuprum vitriolatum.

Moreover, in like manner, the properties of the parts of the chyle ought to be different when any one other of the ſeveral ſpecies of matter which may be employed for food are uſed; but that is by no means the caſe. The chyle of a cat for inſtance, or

or a dog, wholly living on animal food, is the ſame with, and cannot be diſtinguiſhed from the chyle of an ox or ſheep living wholly upon graſs.

I will ſtill add another argument to elucidate the point, whether chyle can be formed by ſolution or precipitation.

There is no menſtruum that is capable of acting on any ſolvent, but may be applied to it in circumſtances out of the body of a living animal, ſo as to diſſolve or decompoſe it. But if we apply the gaſtric, or any other of the juices which are applied to the food in the ſtomach or duodenum, we cannot by any means form chyle out of the body. The gaſtric juice will coagulate ſubſtances out of the living body as well as within it; the bile will neutraliſe an acid out of the body as well as in it; but by applying coagulating gaſtric juice, the watery fluids of the ſtomach, the ſaliva, the bile, the pancreatic juice, altogether or ſeparately, in no caſe

caſe has chyle or any thing like it ever been formed.

Although, therefore, it is poſſible that a menſtruum might have been produced in the ſtomach, which might have united with one ſpecies of food, ſo as to have formed the different parts of the chyle, in which caſe an animal could have lived on one ſpecies of food, which is actually found to be the caſe; yet the ſame menſtruum could not have been combined with another ſpecies of food, ſo as to form the three parts of the chyle, which are always the ſame in each of their properties. Moreover any of the juices which are applied to the food in the digeſtion, or all of them together, may be applied to the food in circumſtances perfectly ſimilar as far as regards ſolution or precipitation, and yet no chyle can be formed.

On the whole, therefore, there is not the ſmalleſt ground from experiment to affirm, that there is any juice or matter applied to the food in the ſtomach capable of,

or actually uniting with any or all of the ſubſtances employed for nouriſhment, ſo as to form chyle. Neither is there any ground for believing that the chyle is precipitated out of the ſubſtances employed for nouriſhment, and therefore this idea of the formation of chyle ought to be abandoned for want of proof. But it not only wants proof, but every kind of appearance renders it perfectly improbable, and therefore we muſt ſearch for ſome other operation, by which the ſubſtances employed for nouriſhment can be converted into the three eſſential parts of the chyle.

Another idea which, as well as the two we have already gone through, has been taken up during almoſt all ages, is, that vegetable ſubſtances in order to be digeſted would go through the vinous and acetous fermentations, and the firſt ſtage of the putrefactive, ſo as to be formed into a mucilage, which, if it proceeded in putrefaction, would produce the ſame ſubſtances that any animal mucilage produced when it putrified,

trified, and was therefore animalized as it was called; and that animal ſubſtances alſo went through the firſt ſtage of putrefaction in the digeſtion. This opinion is held ſtill in a greater or leſſer degree by many phyſiologiſts.

The ground of this opinion is, that if we take a quantity of vegetable ſubſtances, of almoſt any ſpecies, put them in a bag ſimilar to the ſtomach, or into a dead ſtomach, keep them moiſtened with water in the heat of the human body, that is in a heat of about 98° of Fahrenheit's thermometer, and in conſtant motion, that is to ſay, in circumſtances as nearly ſimilar as poſſible to thoſe to which they are expoſed in the ſtomach, a ſaccharine, acetous, and vinous fermentation takes place, or at leaſt the acetous fermentation, acetous acid being certainly produced, afterwards the maſs putrefies, and by the firſt putrefaction vinegar is converted into a mucilage.

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There being no ground on which we ſhould ſuppoſe that there is any difference between vegetable matters contained in a living ſtomach and a dead ſtomach, under the circumſtances that have been pointed out, it was ſuppoſed to be proved by experiment that the ſaccharine, vinous, and acetous fermentations, and the firſt ſtage of the putrefactive, actually took place in a living ſtomach.

Farther, we find it happen frequently that a quantity of acid is brought up by vomiting; which acid being ſaturated with kali, that is, what was formerly called fixed vegetable alkali, produces kali acetatum, formerly called regenerated tartar, or ſal-diureticus. This obſervation appears to confirm by experiment the doctrine of the ſame changes happening in the living and in the dead ſtomach. But there are great grounds for controverting this opinion, ſo ſtrong as in my opinion to render it totally inadmiſſible.

In the firſt place, the ſituation of many of the fluids in the human body, and thoſe of other quadrupeds, and even in almoſt all animals, is in many caſes nearly the ſame with thoſe we can put them into out of the body of a living animal, and yet the ſame changes do not take place. For example, the blood does not putrify in the veſſels of a living animal, although if contained in the veſſels of a dead animal in the ſame heat, and in all other circumſtances as ſimilar as poſſible, it putrifies in a few hours. The coagulable lymph remains fluid in the veſſels of a living animal, but coagulates immediately on extravaſation.

This gave me a ground of doubt, whether the ſame changes took place in the food in the ſtomach of a living animal, that did in the ſame circumſtances as far as they could be copied, excepting not being in the ſtomach of a living animal. I therefore gave ſeveral dogs meat alone, and killing them in about four hours afterwards, on examining the ſubſtances at the beginning of

the duodenum I found no acid, or at leaſt not any that could be traced by the change of colour of vegetable juices. I gave to other dogs in like manner bread by itſelf, and bread along with meat; on examining the matter after about the ſame length of time, that had paſſed into the beginning of the duodenum, I found in both caſes that there was not a ſufficient quantity of acid to change the colour of the juice of violets, but upon applying the juice of black cherries, the brightneſs of the red that immediately enſued, ſhowed evident acidity. One thing farther ſuggeſted itſelf, that bread was not the natural food of the animal on which the experiment was made; that therefore ſome ſmall portion of this vegetable ſubſtance might be not perfectly digeſted, but elude the powers of the ſtomach, and go into the ſame fermentations it would have done in circumſtances nearly ſimilar out of the body. I ſtill doubted whether formation of acid was any part of the digeſtive proceſs, and therefore conceived the idea of examining the fact in ſheep and

cows,

cows, whofe natural food is entirely vegetable. On examining the matter in the beginning of the duodenum in thefe animals, I did not find the leaft trace of acidity, it not altering the colour of red cherry juice, the litmus, nor any other vegetable juice, of which I tried feveral. Mr. Hunter, occupied always in experiments, equally well conceived and accurately executed, had much about the fame time or before found no acid in the previous or digeftive ftomach of rabbits, and other animals of the fame kind. I am led to conclude, therefore, that the formation of acid in the ftomach during digeftion, is always produced by the digeftion not going on perfectly, the powers of the ftomach not being fufficient to overcome the difpofition of vegetable fubftances to run into the faccharine, vinous and acetous fermentations, and that when the organs of digeftion are weak or difordered, or when we give an animal food not adapted to its organs of digeftion, a greater or lefs portion of the food is not governed by the ftomach, but runs into the fermentations

which would arife if they were not influenced by its power.

Another point is ftill to be taken into confideration for the elucidation of this argument.

The mucilage produced by putrefaction is in no way fimilar to either of the three conftituent parts of chyle. If we take vinegar and place it in a heat of 100° of Fahrenheit's thermometer, a film forms on its furface, which when it becomes of a fufficient degree of thicknefs, falls to the bottom, and a frefh film begins to form, and goes on in the fame manner. This film confifts of a mucilage and water, which does not diffolve in water without going through farther change. There is alfo another mucilage produced, which is foluble in water, and not coagulable by heat. Now neither of thefe mucilages are any way fimilar, either to the mucilage of the chyle, which is coagulable on extravafation, nor to that mucilage which oozes out from it, nor to the globular particles; therefore, the firft

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ſtage of putrefaction does not form vegetables into chyle, much leſs does the firſt ſtage of putrefaction form animal ſubſtances into chyle; for if meat be exhibited to a dog which is already fœtid and tender from putrefaction, and the dog be killed in half or three quarters of an hour afterwards, and the meat in the ſtomach examined, it is found firmer and free from fœtor, ſo far is putrefaction, or any of its ſtages, from being the operation carried on in the ſtomach during the digeſtion.

The changes which take place in the ſubſtances capable of giving nouriſhment, and therefore of being converted into the three eſſential parts of the chyle, are totally different from thoſe changes which take place any where but in the ſtomach, duodenum, and jejunum when alive, therefore no experiment made any where, excepting in theſe inteſtines in the living animal, can in the ſmalleſt degree influence the doctrine of digeſtion. It muſt alſo be farther obſerved, that when food is thrown into a ſtomach not

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in perfect health, no conclusion can be drawn from any substance produced by any change of the matters thrown in, for we have already seen that in a stomach not in health, there is not sufficient power to correct the acescency of vegetable food. So in like manner we find in a stomach not in perfect force, that animal food will putrify, although in a stomach in perfect force, not only putrefaction will not go on, but will be even stopped, and the appearances of it destroyed, as in the experiment before recited. Farther, we find that men unaccustomed to live on animal food alone, if they are fed with such food, especially if it be salted, will have putrefaction in many instances produced in their fluids, although men, such as the inhabitants about the mouth of the Orange River, in Africa, live always on animal food, such as whales, seals, limpets, and what fish they can catch; that many times their food has entered into a great degree of putrefaction, and there is no vegetable food whatever employed at the same time; probably most

moſt of them never taſted any vegetable ſubſtance in their lives, excepting aromatics for ſeaſoning; yet they are perfectly healthy and free from all putrefaction in their fluids or ſolids, though they are not very careful of avoiding it in the exterior parts of the body. We ſee likewiſe maggots live in and upon putrid maſſes, while they themſelves and all their fluids are perfectly ſweet and free from all appearance of putrefaction. Experiments to be concluſive with regard to the digeſtion muſt be made not only in the ſtomachs which are alive, but they muſt be in perfect health and vigour, and even food muſt be exhibited, for which they are naturally formed, and nothing muſt be introduced which may put them into diſorder, or alter their action on the food.

If we examine all the experiments that have been made on this ſubject according to this rule, we ſhall find moſt of them ſomewhat ſimilar to the experiment propoſed by the late Dr. Johnſon, to wit, to mix the water from the famous pump in the Temple with

with that of the ciſterns in Grand Cairo, to explain the generation of gold. Accordingly we find nothing but eternal vagueneſs and uncertainty of opinion on this ſubject.

It may perhaps, however, be poſſible to draw ſome concluſions from whence ſome uſeful elucidations may ariſe, from obſerving what happens in ſound and healthy ſtomachs on the digeſtion of the food.

Firſt, we ſee that one ſubſtance, farinaceous matter, is converted into another ſubſtance, chyle. Farinaceous matter forms one ſpecies of matter only; chyle conſiſts of three ſpecies mixed together. Let us conſider what is the operation by which one ſpecies of matter may be converted into the three other ſpecies.

It is impoſſible to conceive that the Almighty is conſtantly annihilating the attractions and repulſions of bodies, and giving them new attractions and repulſions.

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We find that by combining two ſpecies of matter together, each of them loſes its particular qualities, and gains properties entirely independent of the properties of either of the ſubſtances of which it conſiſts, excepting when another ſpecies of matter is applied which has a greater diſpoſition to unite with one of the two ſubſtances of which it conſiſts, and therefore actually does combine with one of them, forming with it alſo a ſpecies of matter totally different and diſtinct. As for example, vitriolic acid combines with iron, ſo as to form a new ſubſtance, ferrum vitriolatum, which is in all its properties perfectly different from either vitriolic acid or iron. The properties of the ferrum vitriolatum are not only different, but abſolutely independent of either the properties of the acid, or the properties of the iron, excepting we apply zinc which has a greater diſpoſition to unite with vitriolic acid, with which it does actually unite, and ſeparates the iron forming with the acid zincum vitriolatum, ordinarily called white vitriol, which is a new and perfectly

perfectly distinct species of matter, It is clear, therefore, and indeed since the time of Mr. Boyle's making this discovery has been gradually making its way, and is an universally received opinion, that the properties of compound bodies depend upon their combination, not upon the properties of their elements. It is farther to be remarked, that two substances may be combined together, so as to form a third which may be considered as an element capable of uniting with another element, so as to form a compound also perfectly new in its properties. For instance, muriatic acid may unite with ammonia pura, or as it has been called, caustic volatile alkali, so as to form ammonia muriata, formerly called common sal-ammoniac; and this ammonia muriata may unite with the calx of copper, so as to form a blue salt, perfectly different in its properties from the muriatic acid, the ammonia pura, the ammonia muriata, and the calx of the copper, *excepting as has been before excepted.* In this combination the calx of copper is not united with the muriatic

muriatic acid, or with the ammonia pura, but with the ammonia muriata, as is clear, becauſe if we unite the calx of copper with the muriatic acid, the ammonia will ſeparate it, therefore ammonia and calx of copper cannot be united with muriatic acid at the ſame time. So in like manner, if the calx of copper be combined with the ammonia; if we apply muriatic acid, the muriatic acid will unite with the ammonia, and ſeparate the calx of copper from it; ſo that ammonia cannot be combined with muriatic acid and copper both at the ſame time; and therefore the calx of copper muſt be combined with the ammonia muriata conſidered as an element.

If we have three ſpecies of matter, and take one particle, or ſmalleſt integrant or poſſible part of each, which ſmalleſt integrant parts we ſhall call A, B, C, A may unite with B, and form a compound M, which may unite with C, and form a compound particle X; or, A may combine with C, and form a compound N, which may combine

with B, and form a compound particle Y, and B may combine with C, and form a compound O, which may combine with A, and form a compound particle Z; therefore the compounds X, Y, and Z, contain in them the ſame matter exactly, to wit, one of the ſmalleſt integrent parts A, B, C, of three diſtinct ſpecies of matter, and theſe three compounds differ from one another, therefore, not in their elements, or ſubſtances of which they conſiſt, but in the manner in which they are combined. We have here then an operation which may poſſibly take place, by which one ſpecies of matter may be converted into another ſpecies, ſo that the whole matter in the one ſpecies may all be contained in the other ſpecies, and that without any addition of any other matter whatever.

Again, ſuppoſing we have four particles of matter, A, B, C, D, theſe four may be combined into one: that is, A may combine with B, ſo as to form M; and C may combine with D, ſo as to form N; M

and N may combine together, ſo as to form one compound X; this compound may be decompoſed, ſo that A may combine with D, and form a compound O, and B may be combined with C, and form a compound P, which compounds O and P may not be capable of combining together; ſo that from the compound X, two other compounds, O and P, may be produced; therefore from one ſubſtance it is poſſible that two others may be produced containing exactly the ſame matter, and without the addition or application of any other ſubſtance to it.

If we find, therefore, when one ſpecies of matter is converted into another ſpecies, that the ſame elements are contained in the matter which we had originally, and the matter which is found after the operation, it cannot be doubted but that the operation which has taken place, is a ſeparation of the elements from one another, and a recombination of them in a new manner. The farinaceous matter contained in barley

is converted into ſugar without any addition or application to the farinaceous matter; but barley and ſugar contain the ſame elements; we may, therefore, conclude that it is by this operation that this converſion takes place.

That barley and ſugar contain the ſame elements is ſhown in this way. It muſt be admitted that any compound, when pure, always contains the ſame elements. Thus kali nitratum, or as it is commonly called nitre, conſiſts of kali and nitrous acid, and every particle of nitre conſiſts of theſe two elements, ſo that whenever we have nitre, we are ſure to have kali and nitrous acid.

Farther, therefore, if we put the farinaceous matter of barley into a glaſs retort, and diſtill it by itſelf, we obtain empyreumatic oil, an acid, and water diſtilled over, and there remains behind charcoal. If we put ſugar into a retort and diſtill it by itſelf, we alſo obtain the ſame empyreumatic oil, water, and the ſame acid, and there remains behind charcoal ſimilar in all its properties.

perties. We get, therefore, four ſubſtances, to wit, empyreumatic oil, water, an acid, and charcoal, from the convertible ſubſtance farinaceous matter, and the ſubſtance which it is converted into, to wit, ſugar. If theſe four ſubſtances be the moſt ſimple elements, then farinaceous matter and ſugar are conſtituted of the ſame ſubſtances or elements. Or if any or each of theſe four ſubſtances be compounds, being the ſame when procured from farinaceous matter, and when procured from ſugar, they contain the ſame elements. Farther, that the change of the farinaceous matter into ſugar is by the elements being ſeparated from one another, ſo as no longer to be combined in the manner that they are united in farinaceous matter, but that they are ſeparated from one another, and re-combined in a new manner, ſo as to form ſugar a new compound *.

In like manner a piece of a muſcle being thrown into the ſtomach, and paſſing through the organs of digeſtion, is con-

* The vapours obtained are here neglected, but they are alſo the ſame from both.

verted into chyle; for the muſcle and the chyle both contain the ſame elements, as is proved in like manner, by putting the muſcle into a retort, and diſtilling it by itſelf, there will come over empyreumatic oil, volatile alkali, and water, there will remain in the retort charcoal; if we alſo put chyle into a retort and diſtill it by itſelf, there alſo come over empyreumatic oil, volatile alkali and water, there remains in the retort charcoal. The empyreumatic oil, volatile alkali, water, and charcoal, which are procured from the muſcle and from the chyle, are perfectly ſimilar to one another in all their qualities, as far as can be inveſtigated by any experiments that could be contrived. If therefore theſe four ſubſtances be ſimple ſpecies of matter, the muſcle and the chyle contain the ſame elements; the only difference is, that theſe elements are combined together in a different manner. Or if the empyreumatic oil, volatile alkali, water, and charcoal, are not themſelves elementary, ſtill theſe conſiſt of the ſame elements; that is, the empyreumatic oil from

from the muſcle contains the ſame elements with the empyreumatic oil from the chyle; the volatile alkali, water and charcoal, in like manner contain the ſame elements, whether they be obtained from the one or the other, or if they were obtained from any other ſubſtance whatever.

It appears then that the muſcle and the chyle do not differ from one another in any other reſpect, excepting that the elements of which they both equally conſiſt, are united by one mode of combination in the muſcle, and in another mode of combination in the chyle. That the converſion, therefore, of the muſcle into the chyle is a ſeparation of its elements from one another, and a recombination of them in a different manner, ſo that the compound ſhall have new properties.

By a parity of reaſoning it may be proved, that all animal food in being digeſted or converted into chyle, has the effect produced by a ſeparation of its elements from one an-

other, and recombination of them in a different manner, ſo as to form chyle a new compound; and likewiſe, ſince by putrefaction farinaceous matter, and all other vegetable food may be made to yield exactly the ſame ſubſtances with animal ſubſtances, particularly with chyle; that is, nitrous and muriatic acids, volatile alkali, water, volatile hepar ſulphuris, gas, inflammable air, calcareous and argillaceous earths; as theſe are the ſame, whether vegetable food or chyle be putrified, it follows that vegetable food likewiſe contains the ſame elements with chyle, and that theſe elements are only ſeparated from one another, and recombined in ſuch manner as to produce and become chyle.

Digeſtion then is performed on ſubſtances containing all the elements of chyle. Theſe ſubſtances in the ſtomach, and other organs of digeſtion, have their elements ſeparated from one another by the effects of the ſtomach, and other organs of digeſtion, upon them, occaſioning in them a decom-

decompoſition and recombination of their elements into a new ſubſtance.

Suppoſing that I have proved that food is not formed into chyle, by being combined with any watery or other menſtruum, by being rubbed down into fine particles, or by undergoing any part of the ſaccharine, vinous, acetous, or putrefactive fermentations, but by a decompoſition and recombination of the elements of the food which requires no additional matter, nor that any ſhould be taken away, can any advantage be drawn from ſo abſtracted an argument.

We are now to endeavour to underſtand by what power a compound may be decompoſed, and its elements reunited in a new manner.

Every perſon, in the ſmalleſt degree acquainted with the principles of chemiſtry, knows that changes are produced on bodies

by their diſpoſitions to unite with one another, which we call their attractions: Suppoſing then we have three ſubſtances combined with one another in a certain manner, but there is another mode of combination, in which they are more diſpoſed to combine, in conſequence of their attractions, in that caſe we might expect that they would ſeparate from one another, and combine according to the mode of combination they were moſt diſpoſed to, and therefore they would immediately change their combination, and in conſequence their properties; that therefore if the ſubſtances of which a muſcular fibre conſiſts, had a greater diſpoſition to unite with one another in the manner that they are combined in chyle, than in the manner they are united; then a muſcle would always and immediately be converted into chyle, in whatever circumſtances it is placed, and that therefore a muſcle could not exiſt for a moment of time, but would always and immediately become chyle.

It is to be obſerved, however, that when two ſubſtances have a diſpoſition to unite with one another, or to decompoſe one another, it is not ſufficient that they ſhould have this power; it is neceſſary alſo that they ſhould be put into certain circumſtances in which the powers of combination and decompoſition are capable of acting. Thus, for example, nitre and ſal ammoniac, or according to their preſent names, kali nitratum, and ammonia muriata, being rubbed together to a fine powder, do not affect one another, nor do they affect one another if they be diſſolved in water; but if we melt them together, they decompoſe one another, nitrous acid uniting with or decompoſing the ammonia, and flying off, and the muriatic acid uniting with the kali. The circumſtance of fuſion is neceſſary to make the elements of theſe two neutral ſalts exert their powers of decompoſition and recombination. That, however, is not the caſe in other inſtances; for ammonia vitriolata, and natron muriatum, or as it is commonly called ſea-ſalt, being diſſolved in water, will decompoſe one an-

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other, the vitriolic acid uniting with the natron, or foſſil alkali, as it has been called, and the muriatic acid with the ammonia, or volatile alkali.

So in like manner, vitriolic acid poured upon mercury in the cold, will not combine with its calx; but if heat be applied, that circumſtance will make the combination take place, and the inflammable air be extricated and decompoſed.

Thus alſo ſugar diſſolved in water, and kept in a heat of 40° of Fahrenheit's thermometer, will not have its elements ſeparate, and recombine into wine. But in the ſame manner the action of the powers of the ſtomach, and other organs of digeſtion, upon the food is neceſſary for thoſe powers which occaſion its decompoſition and recombination to act. So that although they are always preſent in the ſubſtances capable of being converted into chyle, yet nevertheleſs they are not exerted, unleſs they are influenced by the action, or circumſtances which they meet with in the organs

organs of digeſtion of a living animal; ſo that no chyle ever has been, and moſt probably never can be produced, excepting in the organs of digeſtion of a living animal.

It would lead me far beyond my preſent ſubject of enquiry to enter into the powers which the living body has over the matter of which it conſiſts, and which it contains. Proof, however, might eaſily be brought, and has been, that under the ſame chemical circumſtances matter differs extremely when living and dead. Food placed in all the chemical circumſtances that can be conceived ſimilar to thoſe in which it is placed in a living ſtomach, will never be converted into chyle, but will undergo other changes totally different. Animal food will putrefy, vegetable food will become acid, and therefore when food is thrown into the ſtomach, there is a conſtant conteſt between the diſpoſition to the change that it would undergo in ſimilar chemical circumſtances, but not in a living ſtomach, and the changes it is diſpoſed to undergo by the action of the living

living organs of digeſtion upon it. If the living power of the ſtomach be ſtrong, it will be perfectly digeſted; if the living power of the ſtomach be weak, it will not be perfectly digeſted; but part of it will undergo thoſe changes it would have undergone, if it had been in the ſame chemical circumſtances, but not acted upon by the living organs of digeſtion. Thus we ſee when the ſtomach is ſtrong, all ſpecies of food readily digeſted and converted into chyle; while in weak ſtomachs, if too large a quantity of food be employed, or food which does not eaſily enter into the digeſtive proceſſes, or food which the ſtomach has not been accuſtomed to act upon, it will in part, or in ſome caſes wholly, be converted into matter which muſt either paſs through the inteſtinal canal, or paſſing into the blood veſſels along with the chyle, muſt be got rid of by ſome proceſs which requires the exertion, and therefore exhauſts the powers of the ſyſtem. Or it may be even converted into ſubſtances which are noxious to the ſtomach and inteſtines themſelves; as for in-

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ſtance, it may be converted into an acid which produces heart-burn, vomiting, &c. Or its effects on the organs of digeſtion may be noxious to the whole ſyſtem, as undigeſted animal food may putrefy while it remains in the ſtomach, and by its operation on the ſtomach produce fever, which has been called violent, putrid, malignant, &c. of which I have known more than one inſtance. Or the food not being digeſted, may be converted into matter, which entering into the blood veſſels along with the chyle, may, while it remains, have bad effects on the whole ſyſtem; as men living on ſalted animal food for the principal part of their nouriſhment, without being accuſtomed to it from their infancy, or for a long time, and without a ſufficient mixture of herbaceous vegetables of looſe texture, will have putreſcent matter carried into their blood veſſels along with the chyle, which will ſo depreſs the powers of the ſyſtem as to make them incapable of overcoming entirely the diſpoſition to putrefaction, which the blood would be thrown into were it left

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in thoſe chemical circumſtances in which it is in the blood veſſels, were it not alive in itſelf, or acted upon by veſſels having a living power.

This reaſoning, therefore, leads me to lay down this rule. That, in the firſt place, food, which for any of the reaſons already alledged is not digeſted, never produces any nouriſhment, and that therefore all the miſchief that ariſes from its indigeſtion affecting the organs of digeſtion themſelves, all the bad effect of noxious matter produced and acting upon the ſyſtem, all the bad effects ariſing from noxious matter getting into the blood veſſels along with the chyle, beſides all the loſs of the powers of the ſyſtem exerted to get rid of the undigeſted food, if even it be not converted into noxious matter, are all ſuffered without the ſmalleſt advantage. This argument, therefore, concludes in this maxim, that neither in health, nor more particularly in diſeaſe, ſhould food ever be uſed in a greater quantity, or of ſuch quality as cannot be made

made by the powers of the ſtomach, and other organs of digeſtion, to enter into, and go through that proceſs which converts it into the three eſſential parts of the chyle.

On the other hand it muſt be obſerved, that ſtrong ſtomachs, and ſtomachs eſpecially habituated to digeſt any particular ſpecies of food, ſo as to convert it into the three eſſential parts of the chyle, derive perfect nouriſhment from ſuch food whatever it be. A Laplander thus lives upon rein deer alone, without intermixing for moſt part of the year any vegetable food. No putreſcent matter is formed in his ſtomach or organs of digeſtion, none enters his blood veſſels along with the chyle.

An inhabitant of the banks of Orange river, in Africa, lives upon limpets, dead and putrid ſeals and whales, without taſting a particle of vegetable food of any kind whatever, excepting aromatics. The inhabitants of this country three centuries ago lived for at leaſt ſix months of the year principally upon ſalted

animal food, without any other vegetable ſubſtance than farinaceous matter, yet no ſea ſcurvy aroſe in them or any other detriment.

It is not then that food of any one, or any other kind, is more or leſs capable in itſelf of affording chyle perfectly good and intermixed with no noxious matter, but different ſpecies of food muſt be ſo adapted to the particular ſtate the ſtomach and organs of digeſtion are now in, in order to be that which is moſt proper, or what is commonly called wholeſome; or in other words, no food is in itſelf wholeſome or unwholeſome, but as it is compared with the preſent ſtate of the ſtomach and other organs of digeſtion.

The next circumſtance that offers itſelf to our obſervation, is the effect of the coagulating juice of the ſtomach on the food.

Milk is that food which comes neareſt to the chyle in its external appearances, therefore,

fore, and as it is alſo a food which is formed for the nouriſhment of young animals, while their organs of digeſtion are weak, and their growth is at the ſame time very quick, it may be conjectured that they require greater nouriſhment; thus it offers itſelf as an obvious propoſition, that chyle is ready prepared, or nearly ſo, in the veſſels of the mother, in order to ſave the powers of digeſtion in the infant. But we have ſeen that there is a juice contained and conſtantly formed in the ſtomach, which coagulates this food in a few minutes after it is thrown in, retards it in the ſtomach, and retains it there for a conſiderable length of time. This of itſelf would ſufficiently prove, that there is a proceſs which muſt be gone through in the ſtomach itſelf neceſſarily for the formation of the chyle. This is farther confirmed by this coagulating juice producing the ſame effect of coagulating in like manner the white of an egg, which by its properties cannot be diſtinguiſhed from the eſſential part of the ſerum of blood into which it is partly to be converted. This

coagulating juice has an equal effect upon the ſerum of blood itſelf, even of the very ſame animal. Now it never could happen that the ſtomach could have a juice endowed with this property, if it were not neceſſary to arreſt the food in the ſtomach for a certain length of time, in order that it ſhould undergo a change in the ſtomach itſelf. It farther appears from experiment, that food diſſolved in water, ſo as to form a ſolution not capable of being coagulated, and not detained by intermixture with ſolid matter, gives very little nouriſhment in proportion to the ſame quantity of the ſame food given in a ſolid form, or a coagulable one. Thus for example, if a ſolid piece of fleſh be diſſolved in water by ſimple boiling, or by Papin's digeſtion, and exhibited to an animal, it is not capable of being coagulated by the coagulating juice of the ſtomach, and does not give nearly that quantity of nouriſhment which it gives if employed in a ſolid form, without being previouſly diſſolved in water. So in like manner the white of an egg exhibited in a fluid

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ſtate, as it is found in the egg, gives great nouriſhment, as I know from experiment, being coagulable and becoming ſolid in the ſtomach. But if the ſame white of egg be coagulated by heat, and boiled or digeſted in a Papin's digeſter, and ſo diſſolved in water and exhibited, it does not now coagulate from the application of the coagulating juice of the ſtomach, and does not yield nearly the ſame quantity of nouriſhment. It requires, therefore, that the food ſhould be arreſted for a certain time in the digeſting ſtomach of animals, in order there to undergo a certain change. Nor is this only neceſſary in the ſtomachs of men, quadrupeds, and other animals which have compleat ſets of organs of digeſtion, but likewiſe in a leach, polypus, and other animals which have only one cavity, from whence apparently the food is abſorbed after the manner in which the veſſels of plants take their food from the earth, in theſe animals food remains for a conſiderable time in the ſtomach, and undergoes a change before it enters into their other veſſels.

In ſome animals the food is detained, as I have already ſhown, in cavities, before it comes into the digeſting ſtomach. In Mr. Hunter's paper on Digeſtion, publiſhed by the Royal Society, there is this obſervation, which affords very ſtrong ground to found a knowledge of the cauſe and uſes of theſe previous ſtomachs; milk ſucked by a calf does not remain in any of the previous ſtomachs, but paſſes down inſtantly into the digeſting ſtomach, not requiring any previous operation, but graſs remains for a length of time in the previous ſtomachs. It is therefore the nature, that is to ſay, the qualities of the food which renders it neceſſary that it ſhould remain in theſe previous ſtomachs.

Let us conſider what theſe qualities are, by obſerving what food is actually accumulated and detained in the previous ſtomachs.

Firſt then, thoſe animals which live entirely or moſtly upon the fibrous parts of vegetables

vegetables have previous ſtomachs. Theſe fibres are, as I have already obſerved, evidently not digeſtible in the human body, nor in the bodies of ſuch animals as have not previous ſtomachs, excepting in ſome animals, which by men, and for the uſe of mankind, had been brought out of their natural habits of life, and altered entirely in their mode of living, and from which, therefore, we can draw no concluſion. All quadrupeds which we know diſtinctly in their natural ſtate to live only or principally upon the fibrous parts of vegetables, have previous ſtomachs. We may ſuppoſe, therefore, that ſome alteration ſhould neceſſarily happen to the fibrous parts of vegetables before they enter into the digeſting ſtomachs of quadrupeds.

One might readily ſuppoſe that the ſaccharine, vinous, and acetous fermentations might take place in theſe vegetable fibres, or ſome part of them at leaſt. That the acetous fermentation does not take place in theſe previous ſtomachs is quite evident,

becaufe not only no proportion of alkali, however fmall, can be faturated by food juft as it is entering into the digefting ftomach, nor can the colour of any vegetable juice which is acted upon by acids, fhow the fmalleft degree of acidity. There not being, when the animal is in perfect health, the fmalleft quantity of vapour to be found in thefe previous ftomachs, it cannot be imagined that the vinous fermentation takes place; not but that in quadrupeds of the ruminating clafs, fuch as the cow, when thefe previous ftomachs are not fufficiently powerful to prevent the natural fermentations which would take place in fimilar chemical circumftances, only not in a living and powerful ftomach, vapour is actually extricated in fuch quantity as to produce tumor, which is fatal, as I have feen myfelf in feveral inftances; but when thefe previous ftomachs are powerful enough to prevent the ordinary fermentations as above, there is no vapour found, nor any acid. The faccharine fermentation is not marked with fuch obvious circumftances as to determine,

termine, without an inveſtigation by experiment, which I have not been as yet able to contrive or enter into. The only analogy is, that graſs thrown together with a ſmall degree of moiſture ferments, as is ſhown by the heat it acquires, and contains a larger quantity of ſugar, as has been proved; not only by the greater ſweetneſs of taſte, but from actual extraction, and gives more nouriſhment than if it had been ſimply dried, without being converted into hay, as is known to every farmer. Yet I cannot allow myſelf to believe, that even this fermentation takes place in the previous ſtomachs of quadrupeds which live on, and are nouriſhed by, the fibrous parts of vegetables. I ſhould rather think with Mr. Hunter, that in the previous ſtomachs of quadrupeds living upon the fibrous parts of vegetables in a great degree, that it was ſoftening only, and freſh trituration in ruminating animals, that rendered their food more apt or capable of entering into the proceſſes which take place in the digeſting ſtomach.

Yet, neverthelefs, it may be, that fome procefs may take place in the previous ftomachs of animals ufing this food which may decompofe the matter, and reunite its particles into a new compound, which may be fitted to undergo a frefh change in the digefting ftomach.

As to other fpecies of food which are accumulated in one cavity, fuch as the craw of a bird, that accumulation feems merely, becaufe the gizzard, in which it is to be ground into fmall particles for the digefting ftomach, is not large enough, and is improper to grind that quantity at once, which is to be paffed from the gizzard in order for its digeftion. In the craw and gizzard they feem not to be altered at all, excepting in fo far as they are foaked in watery fluids, the craw and gizzard as living parts of the body, having no power over them, farther than preventing them from entering into the faccharine, vinous, and acetous fermentations, as they would do, as has been already infifted upon. Poffibly then

then a change of combination, and confe-quently of properties, may happen in the previous ftomachs of ruminating animals, converting the fibrous parts of vegetables into another fubftance, which may be capable of undergoing a frefh change in the digefting ftomach, and it may alfo be poffible that the bulging part of the digefting ftomach may in fome cafes produce this change, if fuch an one actually takes place.

In the human ftomach, where the different fpecies of food which I have enumerated, are capable of being converted into chyle, it can hardly be doubted that a decompofition and recombination takes place, but this decompofition and recombination does not appear to be the formation of chyle.

Firft, I conclude, that there is a decompofition and recombination of the elements of the food; becaufe, as has been before obferved, milk, ferum of blood, and other fubftances moft fimilar to the chyle and blood to be produced, are coagulated and arrefted

arreſted in the ſtomach, in order to undergo a change, and do not go out of the ſtomach, until the firmneſs and texture of that coagulum is entirely diſſolved and deſtroyed. Secondly, ſolid food, as has alſo been obſerved, when given in a ſolid form, or in ſuch a ſtate as is capable of being rendered ſolid in the ſtomach by coagulation, yields a much larger quantity of nouriſhment than it does, if it be diſſolved in water, ſo as to paſs ſoon out of the ſtomach, and not remain until it undergoes the action of its powers. In the next place, although it is the nature of that operation by which one compound is converted into another by the particles of the different ſpecies of matter, of which it conſiſts, ſeparating from one another, and recombining in a new manner, ſo as to form a freſh compound, without admitting freſh matter into it, to be inſtantaneous: ſo that the ſmalleſt integrent part of one compound in an infinitely ſmall quantity of time is converted into a ſmalleſt integrant part of a new compound; and as ſoon as the operation begins, it may be concluded in an

extreme ſmall quantity of time; and all the ſmalleſt integrant parts of one compound may be converted into all the integrant parts of the other compound; ſo that in one inſtant we may have the whole materials as much changed, as if that which was this moment a cup of glaſs may in the next be a cup of gold: this does not happen commonly; for when ſuch changes take place, a few of the ſmalleſt integrant parts of the one body are converted into a few of the ſmalleſt integrant parts of the other body, and as ſoon as the operation commences, there is an admixture of the firſt and ſecond compound. Thus, for inſtance, when farinaceous matter is converted into ſugar by this kind of operation, the whole maſs is compleatly farinaceous matter before the operation commences; but after the firſt inſtant of the operation there is a quantity of ſugar formed, and as much leſs farinaceous matter left; that is, ſuppoſing there were at the beginning one hundred of the ſmalleſt poſſible parts of farinaceous matter, after the firſt moment of the operation

tion there might be perhaps 99 particles of farinaceous matter left, and one particle of ſugar formed; which ſugar would be as perfect ſugar as that which is produced at the end of the operation. Therefore the converſion does not take place by ſuch ſucceſſion, that firſt, one property is given to the matter to be changed, then another, and ſo on until it becomes perfect. It is not as when we ſow the ſeed of a plant, that a new plant to be produced acquires firſt a radicle, then a plumel, then a ſtem, leaves, flowers and fruit, but it is as if the whole plant was generated at once in all its parts and all its perfection. As this is to be conſidered as the ſtate of the operation, ſuppoſing farinaceous matter to be the food to be digeſted, a particle or particles would be compleatly and inſtantly changed into another ſubſtance, viz. the matter formed in the ſtomach, which matter cannot be chyle; for if it was into chyle, then the abſorbents which are numerous in the ſtomach would take it up as

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faſt as it is produced, and would have the appearance of, and actually be lacteals, and be perceived: now, if we open a living animal at any time of the digeſtion, there is no appearance of any chyle abſorbed from the ſtomach, and therefore we may, and muſt conclude, that there is none there to be abſorbed.

If we throw milk into a portion of the jejunum, that milk will be abſorbed by the lacteals; but if we throw milk into the ſtomach of the ſame animal, the milk will not be abſorbed by the lymphatics; therefore an argument might be brought that the abſorbents of the ſtomach would refuſe what the abſorbents of the jejunum would readily take up. But it muſt be conſidered that the milk is inſtantly coagulated in the ſtomach, and not in the jejunum, which coagulation will perfectly prevent it from being abſorbed; but all thoſe ſubſtances which are not changed by the coagulating juice of the ſtomach will be, and are equal-

ly taken up by the lymphatics in the ſtomach and lacteals. Therefore there is a converſion of the food in the ſtomach into a new ſubſtance, whoſe properties are at preſent unknown, which new ſubſtance is the only one which can be converted into chyle in the duodenum and jejunum, exactly as we may form farinaceous matter, mucilage, native vegetable acid into wine; but before they can poſſibly be converted into wine, they muſt firſt be formed into ſugar. So in like manner farinaceous matter, gum, and white of egg, are all capable of forming chyle; but before they are formed into chyle, they muſt be converted into a matter certainly not ſugar, but a matter of a particular ſpecies in the ſtomach, and by the operation of the ſtomach, this particular ſpecies of matter is afterwards converted into chyle in the duodenum and jejunum.

This operation, which forms part of the whole digeſtion, and which is performed in and is proper to the ſtomach, is one of

thoſe operations which depend on the action of the living ſolids upon the fluids, which appears clearly from various circumſtances which I have already ſet forth. Firſt, the interior ſurface of the digeſting ſtomach is quite different, as I have already ſhown, from the ſurfaces both of the œſophagus, previous cavities, duodenum, and jejunum, being formed as it were of cells, including ſmaller cells in gradation, ſo as to give an immenſe living ſurface to act upon the food, and ſo give it the circumſtances of the operation peculiar to the ſtomach, and overcome the natural diſpoſition of the food to run into fermentations, that would out of the ſtomach convert it into wine and vinegar, or into putrid matter. Moreover, if we take a ſolid piece of meat, put it into a bag ſimilar to the ſtomach, moiſten it with water, keep it in the ſame degree of heat, and other chemical circumſtances, ſuch as we find in the ſtomach, it will remain ſtrong and firm in its conſiſtence for more than twenty-four hours; whereas in the ſtomach when ſufficiently powerful it is broke down,

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and its texture ſo entirely deſtroyed as to be perfectly diffuſible, or at leaſt miſſable with water, in leſs than ſix hours; but if the ſtomach be weak, it will remain there for days, as I have already ſaid; therefore the operation of the ſtomach is ſuch as to occaſion ſolids to be broken down much more readily than they otherwiſe would be, not by the force of grinding, but by a change of the food into the matter produced in the ſtomach. In the next place, the muſcular fibres of the ſtomach are ſuch, and in ſuch directions as to roll the ſubſtances round and round, and bring them near, and apply them to the living parts, ſo as to keep the whole perfectly intermixed, and ſucceſſively acted upon by the living ſurface of the ſtomach, ſo as to keep up the operation in the whole maſs equally.

When a living ſolid acts upon a fluid, ſo as to affect its properties, it ſeems to act at a certain diſtance, and therefore, although matter not actually in contact with the ſurface of the ſtomach may be digeſted, yet

yet it does not follow that the digeſtive proceſs, or that part of it which takes place in the ſtomach, does not ariſe from the influence of the ſtomach. For if any ſpecies of food ſhould be ſhut up in a glaſs, ſtone, or other veſſel having holes in it, and be thrown into the ſtomach, the conſtant motion of the ſtomach would be throwing in through theſe holes matters already digeſted, which would paſs out again, and give room for freſh matters to be applied, which would influence the contents of ſuch veſſel, ſo as to bring them into the ſame proceſſes. Thus if we throw wine into a caſk, whoſe ſurface is impregnated with vinegar, and into the middle of that wine we ſhould throw a ſmall caſk with holes in it filled with a farinaceous paſte, the ſides of the caſk impregnated with vinegar would not only give the wine a diſpoſition to be converted into vinegar, but would alſo occaſion the farinaceous paſte encloſed in the ſmaller caſk to be converted into vinegar likewiſe.

The action of the living ſurface of the ſtomach has a greater effect on the ſubſtances contained, becauſe the motion of the ſtomach is ſlow, while the degree of contraction and conſequent preſſure is moderate, as by this means the food will be ſucceſſively applied to the ſurface, and remain upon it for a length of time ſufficient to be affected by it; whereas by a more violent preſſure, food would be ſqueezed out through the pylorus before it was digeſted, and in a more violent motion it would not have been left to have a ſufficient impreſſion, and therefore would not have undergone the proper proceſs of the ſtomach.

The proceſs of the ſtomach is the moſt eſſential in the digeſtion by much. For if every ſpecies of food, whatever it might be, conſiſts, as I have already ſhown, of the ſame elements; and if, as I have likewiſe ſhown, the additions made in the organs of digeſtion are only to direct the decompoſition and recombination of the elements of the food, ſo as to form it into the ſubſtance produced

produced by the procefs of the ftomach, or afford water to it, then the whole action, which is material in regard to the food, is only connected with the ftomach in its peculiar procefs. If this be the cafe, whatever the food may be, whether it be eafily forced into the procefs of the ftomach, or wirh difficulty, yet when actually forced into fuch procefs, and when it has gone through it, and been converted into the peculiar matter formed in the ftomach it becomes the fame. If fuch matter propelled into the duodenum, where it is to be formed into chyle be always the fame, the duodenum will have the power of converting it into the fame chyle; and if the food does not go through the procefs of the ftomach, it cannot be converted into chyle at all, as I have already fhown. There is nothing, therefore, in the whole doctrine of different fpecies of food which can have any refpect to any part of the body, excepting the ftomach itfelf. For food, confidering any fpecies of it as confifting of a vaft number of homogeneous particles, may have every one of thefe particles converted

into the matter produced by the procefs of the ftomach; and that being one fpecies of matter only, will pafs into the duodenum the fame uniform fubftance, whatever the food may have been. Or fuppofing that none of thefe homogeneous particles are at all changed in the ftomach, but pafs into the duodenum as they were when they were fwallowed, in that cafe none of them can enter into the procefs of the duodenum, and be converted into chyle, but muft pafs on and be evacuated. Or fuppofe one half, or any other proportion of the homogeneous particles of one fpecies of food to undergo the operation of the ftomach; and the other half, or whatever proportion it may be, to remain unaltered and pafs into the duodenum; then that part which underwent the procefs of the ftomach when it got into the duodenum would be converted by the procefs of the duodenum into chyle, and that part which did not go through the procefs of the ftomach, would not be capable of going through the procefs of the duodenum, but muft pafs forward and be

evacuated. The firſt, therefore, and great ground on which we are to conſider food, is its diſpoſition to be acted upon by the powers of the ſtomach, in the ſtate the ſtomach is in; for whatever ſpecies of food is thrown into the ſtomach, if it yields to the action of the ſtomach, ſo as to be converted into the matter formed by the proceſs of the ſtomach, it will certainly, the whole of it, be formed into the ſame chyle, and the ſame blood. So that it is perfectly immaterial what it may be, farinaceous matter, animal mucilage, apples, potatoes, wheat, muſhrooms, or oyſters, beef, veal, chicken, ſalmon, or gooſe. So long as it has undergone the proceſs of the ſtomach, and been converted into the matter formed by that proceſs it gives equally good nouriſhment, and is equally innoxious, becauſe it becomes exactly the ſame.

In ſo far, therefore, the whole enquiry with regard to the food will be confined to the conſideration in the firſt place of what ſubſtances can ever be converted into the matter

matter formed in the ſtomach, and which of theſe ſubſtances are adapted to the ſtomach in its preſent ſtate, ſo as that it ſhall be readily brought into the proceſs of the ſtomach, and be converted into the peculiar matter formed by that proceſs.

However, there is another conſideration which I have alſo ſhown the grounds of, that the food may be converted into acid, or putrid, or perhaps other noxious matter, which may hurt the duodenum and lower inteſtines as it paſſes on. It will be therefore alſo a conſideration, whether in deſcribing proper food according to the preſent ſtate of the ſtomach, that part which is not changed into the matter produced by the proceſs of the ſtomach paſſes on ſimply, and undergoes no change, or whether it enters into ſome fermentation in the ſtomach, which may render it noxious to the ſtomach itſelf, or to the duodenum, and other inteſtines which it may paſs through.

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In conſidering proper food, whatever particular ſtate the ſtomach may be in, no man would ever adviſe a food, which although it might be digeſted readily, might at the ſame time, by its own qualities, be noxious. For example, although the poiſon of a rattle ſnake may be digeſted and formed into chyle; yet if there ſhould be the leaſt bit of ſore or wound in the ſtomach, it muſt prove immediately fatal. Much leſs would any one adviſe the uſe of any food found naturally mixed with a noxious ſubſtance, unleſs that noxious matter was firſt ſeparated. Thus many ſpecies of arum contain farinaceous matter, or gum, which are nouriſhing; but mixed naturally with ſo acrid a juice as would often prove poiſonous, excepting when the acrid matter is gone off by keeping it ſome time after it is gathered, then the farinaceous matter and gum are the ſame as when found in any other vegetable. But we are not at preſent to enter generally into practical details with regard to the food.

We are to consider its farther progress after it has passed out of the stomach.

I have already contended, that chyle is not formed in the stomach. Sometimes a little whitish matter is seen about the pylorus; but if it were perfect chyle it would be absorbed, and shown, as I have already said in the absorbents of the stomach, which it is not, even if in the middle of the digestion the pylorus is tied round by introducing a piece of tape, and forming a ligature round it, and retaining the remaining food in the stomach. The matter formed in the stomach is therefore converted in the duodenum, and continues to be converted in the jejunum into chyle.

As the coagulating juice of the stomach, as far as we can judge, does not all, or any part of it, enter into the matter formed from the food in the stomach, and the other juices of the stomach, only in so far as they apply water, these juices of the stomach only assist in regulating the process of the

the ſtomach and the food, ſo neither do the juices of the duodenum, either the bile, pancreatic juice, fluids ſecreted in the glands of the duodenum, or which may paſs through the exhalents, at all appear to enter into any part of the chyle. For if in the body when it is whole a ſtone ſhould obſtruct the ductus communus choledochus, ſo as to prevent bile altogether from getting into the duodenum; or if we open the body of an animal, when food has been thrown into the ſtomach, and tie up the ductus choledochus, ſo as to prevent any bile from getting into the duodenum; in either caſe chyle is formed without any particle of bile being admixed; and the ſame may be ſaid of the pancreatic juice; ſo that chyle is ſolely the product of the matter formed by the digeſtive proceſs of the ſtomach.

Chyle in itſelf is always the ſame, but not always in the ſame quantity in proportion to the food. For in the ſtomach itſelf, when a great quantity of food is thrown

in, part of it may be digeſted and converted into the ſubſtance formed by the proceſs of the ſtomach, and part of it may be ſent into the duodenum to paſs off unaltered; which, however, is often dubious becauſe on examining the food in the duodenum, we hardly ever find any digeſtible matter in the form it was thrown into the ſtomach. If the whole of the food be converted into the matter formed by the proceſs of the ſtomach, in the duodenum part may be converted into chyle, and part be paſſed forward without any farther change. Or that part which was not converted into chyle, may be converted into ſome other ſubſtance which may paſs through the lacteals into the blood veſſels, and be evacuated by the different excretories of the body. Or the whole being converted into chyle, part of that chyle may be formed into blood, and part of it may undergo ſome other proceſs, which may render it capable of paſſing off through the different excretories, or depoſit it in ſome of the cavities of the body out of the courſe of circulation. But all

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this goes far beyond the limits to which I am reſtricted, and therefore I ſhall endeavour to point out what objects I had in view to lay before you.

Firſt, the ſtructure of the organs of digeſtion. Secondly, the matters applied to the food in the organs of digeſtion. In the next place the ſubſtances employed for food. Then to point out that all the ſubſtances employed for food, had all and every one of them the ſame elements exactly, and each of them all the elements neceſſary for the formation of chyle; that is, all the elements that are actually found in chyle. That therefore it was only neceſſary that theſe elements ſhould be ſeparated from one another, and recombined, in order for its formation. That the action of the ſtomach, duodenum, and perhaps jejunum, together with the fluids applied, induced in the matter employed for food one operation, by which its elements were diſunited, and reunited in a new manner, and into a new matter; which matter, although it might

be mixed with other ſubſtances, was in itſelf always the ſame in all its properties, and that this matter was by a new operation induced by the action of the duodenum, and the fluids it met with there, to have its elements again diſunited, and reunited ſo as to form the three eſſential parts of the chyle, which, therefore, could not be influenced in the ſmalleſt degree by the food, and that theſe three eſſential parts of the chyle were always the ſame, and therefore when converted into the blood, the blood a fortiori could not be in the ſmalleſt degree influenced by the food. And moreover, that provided a ſufficient quantity of food was employed, and the organs of digeſtion were ſufficiently powerful in their action, and the fluids applied were properly added, a ſufficient quantity of blood would be formed, and that too large a quantity of food did not produce too large a quantity of blood.

FINIS.